ENGINEERING PRACTICES MANUAL NUMBER 2

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AUGUST 1
1960

Gas anchors pay dividends 75
Nebraska's hottest oil area 78
LPG pilot test pays off 85
Ouachita Mountain prospects 94
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WORLD OIL

A Gulf Publishing Company Publication

SPECIALIZED FOR EXPLORATION, DRILLING AND PRODUCING OPERATIONS AND MANAGEMENT

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ENGINEERING PRACTICES MANUAL NUMBER 2

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Industry's First Complete Fishing Practices Manual

FOR SEVERAL YEARS men in the field, engineering schools and fishing tool manufacturers have been seeking a single source of information on every aspect of fishing operations.

Realizing this need, 12 months ago the WORLD OIL staff asked top authorities in the field to produce a manual that would:

1. Describe typical fishing conditions.
2. Show, step-by-step, how fish are recovered.
3. Describe different types of fishing tools.

The result of their efforts is being published for WORLD OIL readers starting with this issue—and will be concluded in the September 1 issue. The first part describes Cased Hole Fishing Operations. The second, Fishing in Open Hole. Reprints of the Manual will be made available at $1 per copy.

Following is a brief outline of the valuable information contained in this, the first manual of its kind to be published:

Fishing in Cased Hole—Page 47

- Recovery of Liners.....Page 50
- Recovery of Production Packers.....Page 63
- Recovery of Tubing.....Page 69
- Recovery of Rods.....Page 70
- Recovery of Wire Line Tools.....Page 71

Under each of the above headings, you will find a complete, well-illustrated description of methods and equipment used to recover fish under typical conditions. Also, all types of drilling in soft or hard rock, and their allied fishing characteristics are described.

Open Hole Fishing Tools and Methods (September 1 Issue)

I. Recovery of Drill Pipe
   - A. Free point—string shot method
   - B. Washover back-off connector method
   - C. Outside cutting method

II. Recovery of Drill Collar
   - A. Drill collar spear method
   - B. Taper tap method

III. Recovery of Twist-Off Drill Pipe

IV. Recovery of Small Objects

V. Miscellaneous Wireline Tools, Logging Devices, etc

a QUICK LOOK at this issue . . .

THIS ROTARY RIG is typical of the ones used in exploration throughout the Northwest Kansas and Western Nebraska basin. This rig has cut 347 wells totaling 1,200,000 feet, average 3,458 feet per test without major downtime for repairs. It is owned by Empire Drilling Co. of Wichita, Kan. (See story on Page 78.)

BUSY OIL MEN: To help you put first things first, scan these time-saving digests on this and the following pages, checking ☑ those you want to read first.

☐ **Streamline your paperwork . . .** In 1900 one clerical worker was able to handle the paperwork for 30 production workers. The ratio now is reported to be as low as one clerk per worker. For a timely discussion of the reasons for industry's mounting paperwork problem, plus several excellent cost-cutting ideas to reduce paperwork, turn to. . . . . **Page 73**

☐ **Field constructed gas anchors can save money . . .** Increased pump efficiency and increased production can be obtained by proper application of bottomhole separators. Although gas anchors have sometimes been described as inadequate and obsolete, one major operator has found them to be an economical solution to gas interference problems when used in conjunction with proper operational procedures. . . . . **Page 75**

☐ **First Cambrian oil sparks western Nebraska exploration . . .** Discovery of the first Lamotte (Reagan) sandstone oil in Nebraska adds major impetus to the state's exploration effort. Development of Red Willow County's Pennsylvanian oil fields also is progressing at a brisk pace. . . . . **Page 78**

☐ **Sunray's LPG pilot test pays off . . .** Good results have been obtained from a 160-acre LPG pilot flood in Bisti field, New Mexico. An additional 6 million barrels of oil is expected to be recovered through miscible phase flooding of the 7,000-acre Central Bisti Unit. For a detailed discussion of the pilot area plus information on geology, reservoir characteristics, reservoir fluids and production history, turn to. . . . . **Page 85**

Watch for your Drilling Progress

☐ **Ouachita Mountains DO have oil and gas potential . . .** Arguments used to condemn oil prospects of the Ouachita Mountains in particular and of Ouachita facies in general are not well founded. Oil, gas and solid hydrocarbons are present in the Ouachita Mountains. Metamorphism, originally thought to be severe and general, based on cursory geological work, is now known to have been exaggerated. Structural relationships are not completely known, but thrust faulting cannot be used to condemn prospects. . . . . **Page 94**

☐ **How to design a closed rotative gas lift system (Part 2) . . .** A closed rotative system for a single intermittent well represents the worst possible operating conditions, particularly if a time cycle surface controller is used on the injection gas line. This article presents step-by-step sample calculations for such a system. Also included is a discussion of the effect of adding wells to the single system, and a complete sample layout of a multiple well system. . . . . **Page 103**

☐ **How to "live" with your job . . .** Many heart attacks, migraine headaches and ulcers can be traced directly to man's ignorance of himself. In this timely, thought-provoking article, one of the nation's leading psychiatrists frankly discusses the causes of today's "stress" diseases, tells what can be done to curb them, and sheds new light on many outmoded beliefs concerning man's emotions and behavior. . . . . **Page 116**

Oil's economic outlook beginning to brighten

AFTER A PROLONGED period of slower activity and depressed economic conditions, the U.S. oil industry's prospects are beginning to brighten.

In the first place, the general demand picture is improving.

In the second place, the oil industry is succeeding in its efforts to reduce surplus stocks of crude and refined oils.

Complete details of this improvement trend will be published in WORLD OIL's August 15 International Outlook Issue, a "bonus" issue which annually provides the industry's most complete and authoritative report on:

- World-wide activity and economic trends
- Production and drilling statistics
- Detailed reports on more than 110 countries
- Outlook for the U.S. oil industry for the remainder of 1960.

Be sure to watch for your August 15 "bonus" issue!

Issue in October

Oil Industry In Brief

Here are the latest industry trends, revealed by WORLD OIL and industry research:

Demand declines. Domestic demand for all oils dropped 4 percent and exports were off 17.3 percent in June, compared with year ago levels. Gasoline demand remained about the same. Six-month average for all oils: 9,998,000 barrels daily, up 1.8 percent over same 1959 period . . . See Page 25.

Inventories decrease. On June 30, stocks of all oils totaled 787,600,000 barrels, down 3.6 percent from same 1959 date . . . See Page 25.

Crude production down. June crude production averaged 6.8 million barrels daily, down 3.9 percent from year ago levels. However, natural gas liquids production increased 6.7 percent to 923,000 barrels daily . . . See Page 25.

Imports drop sharply. Total imports dropped 14.7 percent to 1,622,000 barrels per day in June. Crude imports averaged 999,000 barrels per day, down 17.1 percent . . . See Page 25.

Prices improve. IPAA reports refinery prices on four major products are recovering from 5½-year low in May, averaging 20 cents per barrel higher in late July . . . See Page 13.

Well completions down slightly. Operators completed 133 wells per day in June, compared with 134 wells daily in May. However, 3,994-well total was up 1.4 percent over June 1959 . . . See Page 28.

Operating rigs decrease. 3,738 rigs were reported operating on June 30, down 14 rigs from May's end—and down 661 rigs or 15 percent from June 30, 1959 . . . See Page 28.

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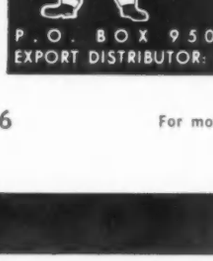

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WORLD OIL (formerly The Oil Weekly) and The COMPOSITE CATALOG for the drilling-producing industry.

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PETROLEUM REFINER and The REFINERY CATALOG for the oil, gas and petrochemical processing industry.

Indexed by Industrial Arts Index and Engineering Index

Looking Ahead

Operators to drill 4.9 percent more wells in last half . . . World Oil's annual mid-year drilling activity survey reveals:

- 23,721 new wells will be drilled in the United States during last six months of 1960, up 1,118 wells or 4.9 percent over the 22,603 new wells completed during first half of 1960.
- Total of 46,324 wells will be drilled in the United States this year, down 6.1 percent from 49,331 wells completed during 1959.
- 98,875,290 feet of hole will be drilled in last half, up 3,753,687 feet or 3.9 percent over first half.
- Footage drilled should total 193,996,893 feet in 1960, down 7.3 million feet or 5.7 percent from 1959.

Areas where drilling activity is expected to increase include California, Colorado, Kansas, offshore Louisiana, Michigan, Mississippi, Nebraska, southeast New Mexico, West Virginia and Wyoming.

Oil and gas in Washington . . . Pressures exerted by coal and other special interest groups in party politics emphasizes the urgent need for oil industry to become more active on Washington scene. Two good examples are fuels policy and anti-depletion planks in Democratic platform. Predictions are that fuels policy, gas bill, depletion, imports control, and tax issues will make the next session of Congress one of the most critical in oil industry history . . . **Senator Saltonstall (R-Mass.)** has proposed that imports Region One (New England area) be redefined to allow more residual fuel imports, citing recent 15 cents per barrel increase for fuel oil in New England . . . **Petroleum prices are starting to recover from 5½-year low in May,** according to IPAA. Considerable progress in reducing inventories and pick up in demand are listed as reasons. Refinery prices for four major products averaged 20 cents per barrel over May, although they still were below last year . . . **Coal groups still are flooding Washington—and the nation**—with thousands of expensive brochures, flyers, and releases in behalf of national fuels policy . . . **Interior Secretary Seaton** says his Department will act quickly as possible to set up Office of Coal Research to increase use and output of coal (as per Coal Research Act signed by President Eisenhower on July 7). Interior Department already has asked Budget Bureau to approve funds request for first year of coal research program. **Question: How many oil and gas industry tax dollars will be used to revive its stiffest competitor?**

Two firms to explore Atlantic Coast areas . . . For the first time, oil groups are showing active interest in Atlantic Coast areas north of Florida (See World Oil, June 1959, Pages 108-111). Interior Department has received applications from Offshore Exploration Group of Houston and Kerr-McGee to explore Georgia offshore area and areas off New Jersey, Maryland, Delaware and Virginia.

Geological Survey has advised Interior Secretary that although no commercial oil and gas reserves have been discovered along Atlantic Coast, it is recognized that possibilities of finding oil and gas increase in a seaward direction because of increasing thickness of sedimentary formations in an easterly direction. Water depths are relatively shallow and exploratory drilling is technologically possible up to 75 miles offshore.

Plaster "pancakes" increase crude production . . . Shell Development has successfully field tested use of plastic in East Texas sandstone formations to curb water production and boost crude output. Plastic hardens just above the water level, sealing it off from oil-bearing formation.

Method shuts off bottom water drives in sandstone formations only, will be used mainly in Gulf Coast and California. In East Texas test, plastic formed in 5-foot radius around the hole. Cost: $100 per vertical foot.

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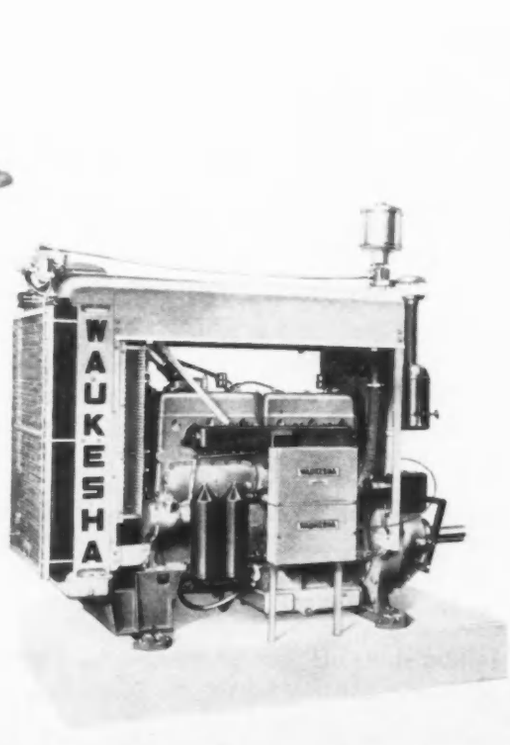

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PHOTO BY JIM THOMAS

Price cutting can be dangerous

LINE UP SEVERAL objects a certain distance apart. Then gently tap the first one. As that one topples, it falls against the next, pushing it down—and so on until each is knocked flat.

This is a game children have played with dominoes for generations.

Industries play the game, too. It is called "Knock the Prices Down." One maneuver pushes against the other until an industry is knocked reeling.

The industry game starts on the world scene. First, tremendous reserves of cheap crude oil are found in the Middle East or Africa. Then, European, South American and Asian refiners play one operator against the other to obtain a price that allows the producer the slimmest possible profit margin. And of course, Russia is helping to push prices down a little more with its underpriced crude.

The game continues on the U.S. scene. Domestic producers, unable to compete with overseas crude prices, have to take the leftovers allocated to them by a mandatory imports program. The leftover markets, during a period of slow demand growth, aren't enough—so producers have to operate on tighter proration schedules and tighter budgets.

In tightening their monetary belts, some producers pit one drilling contractor against another to get the lowest possible bid for the smaller number of wells they plan to drill. And some drilling contractors, having too little faith in their services, wind up either with a too-small profit—or with stacked rigs.

Faced with these problems, some drilling contractors and operators pit one supplier against the other to get the cheapest possible price on parts, equipment and services without regard for published price lists which are available to all. To get the business, some suppliers concede normal price levels.

Result: Some drilling contractors are being forced to use lower quality personnel and equipment. Some suppliers are being forced to cut down the number of stores they operate.

It is recognized that the use of bids to obtain the lowest possible price is accepted as good business under the free enterprise system. However, carrying this—or any—practice to extremes can be harmful. And it appears that such extremes exist today.

There is another important factor in all this. According to the Robinson-Patman Act, both buyer and seller commit unlawful price discrimination when either takes part in a transaction which allows prices to be cut to one buyer in an area in preference over another.

So, unwittingly, some crude producing companies are taking part in a trend that not only may help to eliminate services that save them millions of dollars annually in time and manpower, but they also may be committing unlawful price discrimination in some instances by taking part in preferential price cutting.

Of course, drilling contractors and supply companies are not helping their own solvency one whit by placing too small a value on their own services.

If the above trends continue, the knock-prices-down game will take a disastrous toll, and at least two of the U.S. oil industry's most needed services will be seriously hurt.

It is time to stop playing deadly short-term economic games and to start reviving the team effort that has made the oil industry grow and prosper. It is time to stop worrying about grabbing business regardless of price and to start operating on a fair profit margin that will insure a stronger industry even during these days of depressed economic conditions.

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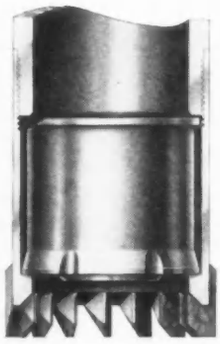

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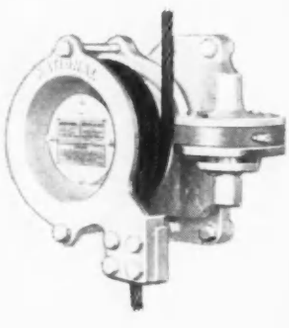

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Industry's situation improves further

THE OIL INDUSTRY'S situation continued to improve gradually in June and July. Efforts to achieve better balance between supply and demand are being rewarded.

Tangible benefits include especially a better market for gasoline, the industry's most important product. Prices of gasoline have been marked up somewhat, at wholesale and retail, in most sections of the country. The prices previously were depressed, and the increases was urgently needed.

Helping to stabilize the gasoline market has been the current strong seasonal demand, which has caused withdrawals from storage and relieved the earlier scarcity of tankage.

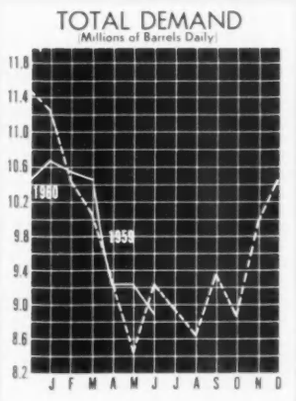
Demand in June. Total demand for petroleum was disappointing in June, after having improved some during the spring, averaging 8,871,000 barrels daily. That was 402,000 barrels or 4.3 percent less than booming (pre-steel-strike) demand in June a year ago. Domestic demand was down 4 percent, and exports were off 17.3 percent.

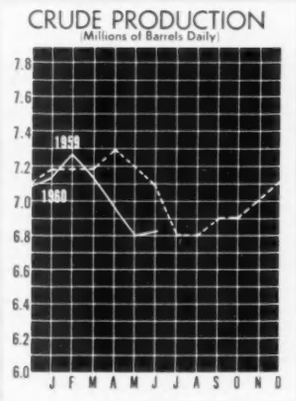
The decrease in demand was caused by declines for distillate fuel oil, residual fuel oil, and miscellaneous products. Gasoline demand was the same as in June last year.

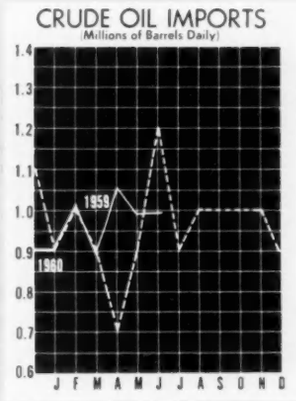
First Half or 1960. For the first half of 1960, total demand for all oils averaged 9,998,000 barrels daily. That was an increase of 175,000 barrels or 1.8 percent over demand in the first six months of 1959. Domestic demand was up 219,000 barrels or 2.3 percent. Exports were down 44,000 barrels daily or 17.5 percent, in averaging only 208,000 bpd.

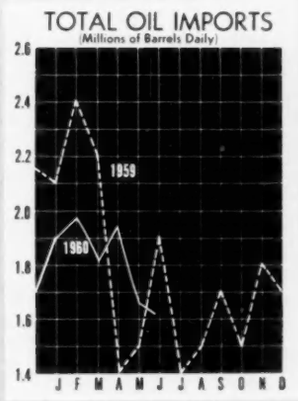
Gasoline demand in this year's first half was 51,000 barrels daily or 1.3 percent larger than in the like period last year, having averaged 4,083,000 bpd. Distillate fuel oil demand was up 44,000 barrels or 2.2 percent at 2,060,000 bpd. Kerosine demand was up 52,000 barrels or 16.6 percent at 365,000 daily. Residual fuel oil demand of 1,717,000 bpd was off 42,000 barrels or 2.4 percent. For all

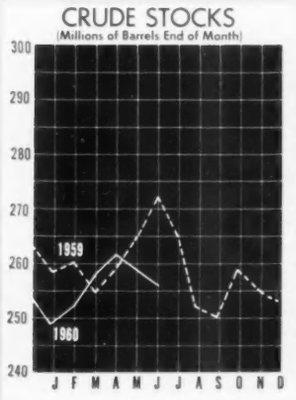
Petroleum Trends...

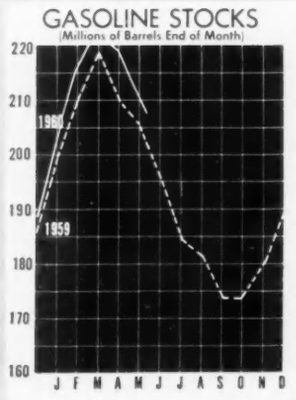


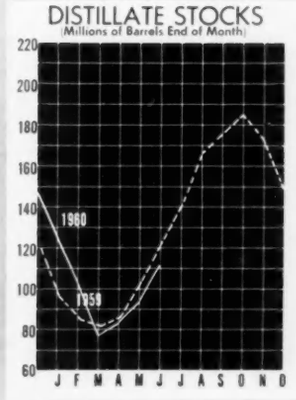


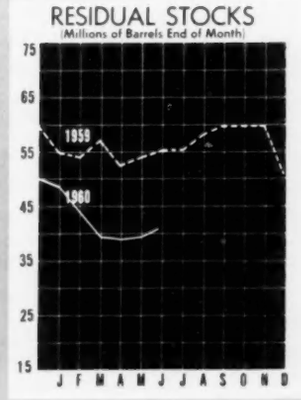












U.S. Petroleum Demand and Supply (Thous. Bbls. Daily)

ITEM	JUNE 1960	JUNE 1959	% Diff.	May 1960	JANUARY-JUNE 1960	JANUARY-JUNE 1959	% Diff.
DEMAND							
All Oils, Total Demand	8,871	9,273	— 4.3	9,274	9,998	9,823	+ 1.8
Domestic Demand	8,656	9,013	— 4.0	9,074	9,790	9,571	+ 2.3
Export Demand	215	260	— 17.3	200	208	252	— 17.5
Gasoline, Total Demand	4,518	4,517		4,290	4,083	4,032	+ 1.3
Distillate, Total Demand	1,229	1,254	— 2.4	1,376	2,060	2,016	+ 2.2
Kerosine, Total Demand	266	154	+72.7	191	365	313	+16.6
Residual, Total Demand	1,290	1,431	— 9.9	1,386	1,717	1,759	— 2.4
Other Oils, Total Demand	1,568	1,917	— 18.2	2,031	1,773	1,703	+ 4.1
CHANGE IN STOCKS							
All Oil, Change in Stocks	+483	+577		+132	165	+149	
NEW SUPPLY							
Total New Supply	9,354	9,850	— 5.0	9,406	9,833	9,973	— 1.4
Domestic Production, Total	7,732	7,948	— 2.7	7,739	7,984	8,066	— 1.0
Crude Oil	6,809	7,083	— 3.9	6,809	7,042	7,194	— 2.1
Natural Gas Liquids	923	865	+ 6.7	930	942	872	+ 8.0
Imports, Total	1,622	1,902	— 14.7	1,667	1,849	1,906	— 3.0
Refined Products	623	697	— 10.6	668	847	946	— 10.5
Crude Oil, Total	999	1,205	— 17.1	999	1,002	960	+ 4.4
Crude, East of California	733	950	— 22.9	691	742	758	— 2.1
CRUDE RUNS							
Crude Runs to Stills	8,090	7,987	+ 1.3	7,930	8,040	8,052	— 0.2
Domestic Crude	7,045	6,937	+ 1.6	6,861	7,043	7,123	— 1.1
Foreign Crude	1,045	1,050	— 0.5	1,069	997	929	+ 7.3

U.S. Stocks of Oils (Million Bbls. at End of Month)

KIND OF OIL	TOTAL IN U.S. June 1960	TOTAL IN U.S. June 1959	% Diff.	TOTAL IN U.S. May 1960	EAST OF CALIFORNIA June 1960	EAST OF CALIFORNIA June 1959	% Diff.	EAST OF CALIFORNIA May 1960
All Oils	787.6	816.6	— 3.6	773.1				
Crude Oil	256.8	272.5	— 5.8	259.5	224.1	234.1	— 4.3	225.9
Gasoline	201.7	196.1	+ 2.9	210.9	171.0	167.6	+ 2.0	178.8
Distillate Fuel Oil	111.7	121.0	— 7.7	93.5	100.2	108.1	— 7.3	82.1
Kerosine	27.5	27.4	+ 0.4	24.7	26.0	27.0	— 3.7	22.9
Residual Fuel	41.2	55.5	— 25.8	39.9	28.3	29.0	— 2.4	27.0
Other Oils	148.7	144.1	+ 3.2	144.6				

U. S. Crude Oil Production, by States (Thous. Bbls.)

STATE or DISTRICT	Daily Average for Month June 1960	June 1959	% Diff.	May 1960	Total, January-June 1960	1959	% Diff.
Alabama	17.9	14.9	+ 20.1	18.6	3,167	2,396	+ 32.2
Arkansas	77.5	81.3	— 4.7	80.6	14,149	14,264	— 0.8
California	837.2	849.5	— 1.5	835.5	151,502	152,840	— 0.9
Colorado	127.8	124.3	+ 2.8	129.6	23,334	22,838	+ 2.2
Florida	1.0	1.2	— 16.7	1.0	197	213	— 7.5
Illinois	209.9	213.5	— 1.7	212.1	38,881	38,914	— 0.1
Indiana	31.9	32.3	— 1.2	32.3	5,814	6,044	— 3.8
Kansas	280.9	328.1	— 14.4	303.9	55,173	60,218	— 8.4
Kentucky	61.5	84.0	— 26.8	63.1	11,092	13,488	— 17.8
Louisiana	1,045.1	944.9	+ 10.6	1,036.0	194,609	171,261	+ 13.6
North Louisiana	113.4	118.8	— 4.6	113.0	21,836	22,012	— 0.8
South Louisiana	931.7	826.1	+ 13.4	923.0	172,773	149,249	+ 15.8
Michigan	38.9	28.8	+ 35.1	37.2	6,716	4,812	+ 39.6
Mississippi	136.5	128.9	+ 5.9	140.7	25,569	22,415	+ 14.1
Mo.-So. Dak.-Tenn.	0.8	0.1	+700.0	0.6	143	19	+652.6
Montana	78.8	84.6	— 6.9	76.1	14,730	14,768	— 0.3
Nebraska	67.9	69.1	— 1.7	59.9	11,480	11,094	+ 3.5
Nev.-Wash.-Alaska-Ariz.	0.9	0.7	+ 28.6	0.9	146	89	+ 64.0
New Mexico	292.7	294.3	— 0.6	302.6	54,447	51,946	+ 4.8
Southeast New Mexico	255.0	248.0	+ 2.8	265.3	46,487	45,032	+ 3.2
Northwest New Mexico	37.7	46.3	— 18.6	37.3	7,960	6,914	+ 15.1
New York	5.2	5.7	— 8.8	4.9	915	978	— 6.5
North Dakota	60.0	51.5	+ 16.5	59.3	10,317	8,887	+ 16.1
Ohio	11.7	16.3	— 28.2	11.2	2,370	2,796	— 15.2
Oklahoma	501.9	535.7	— 6.3	518.5	97,245	100,718	— 3.5
Pennsylvania	16.7	17.3	— 3.5	16.7	3,066	2,979	+ 2.9
Texas	2,459.1	2,705.5	— 9.1	2,417.1	473,657	515,694	— 8.2
Dist. 1: South Central	45.1	46.1	— 2.2	42.9	8,035	8,310	— 3.3
Dist. 2: Middle Gulf	108.4	116.8	— 7.2	106.1	21,363	22,663	— 5.7
Dist. 3: Upper Gulf	349.7	384.6	— 9.1	344.4	65,956	73,221	— 9.9
Dist. 4: Lower Gulf	179.8	186.1	— 3.4	176.5	34,743	36,532	— 4.9
Dist. 5: East Central	26.6	29.3	— 9.2	26.5	5,018	5,693	— 11.9
Dist. 6: Northeast	233.9	256.2	— 8.7	228.1	45,752	51,078	— 10.4
Dist. 7-B: North Central	126.1	132.2	— 4.6	121.5	23,708	25,599	— 7.4
Dist. 7-C: West Central	119.7	125.3	— 4.5	117.0	22,757	24,688	— 7.8
Dist. 8: West	964.0	1,050.5	— 8.2	951.0	188,822	202,790	— 6.9
Dist. 9: North	198.1	207.0	— 4.3	195.1	35,509	37,743	— 5.9
Dist. 10: Panhandle	107.9	106.9	+ 0.9	107.9	19,778	19,407	+ 1.9
Utah	102.2	118.2	— 13.5	103.4	19,423	19,990	— 2.8
Virginia					2	3	— 33.3
West Virginia	6.7	6.3	+ 6.3	6.3	1,118	1,067	+ 4.8
Wyoming	337.8	346.1	— 2.4	340.5	62,299	61,449	+ 1.4
Total, United States	6,808.5	7,083.1	— 3.9	6,808.6	1,281,561	1,302,180	— 1.6

Sources for above 3 tables: Bureau of Mines monthly reports, except last two months based on API and B. of M. weekly reports and WORLD OIL estimates, and all Texas districts from API.

other oils combined, demand of 1,773,000 bpd was an increase of 70,000 barrels or 4.1 percent.

Supply. New supply in June averaged 9,354,000 bpd, a decrease of virtually 500,000 barrels or 5 percent from June last year. Both domestic crude production and imports were held well below last year's trends.

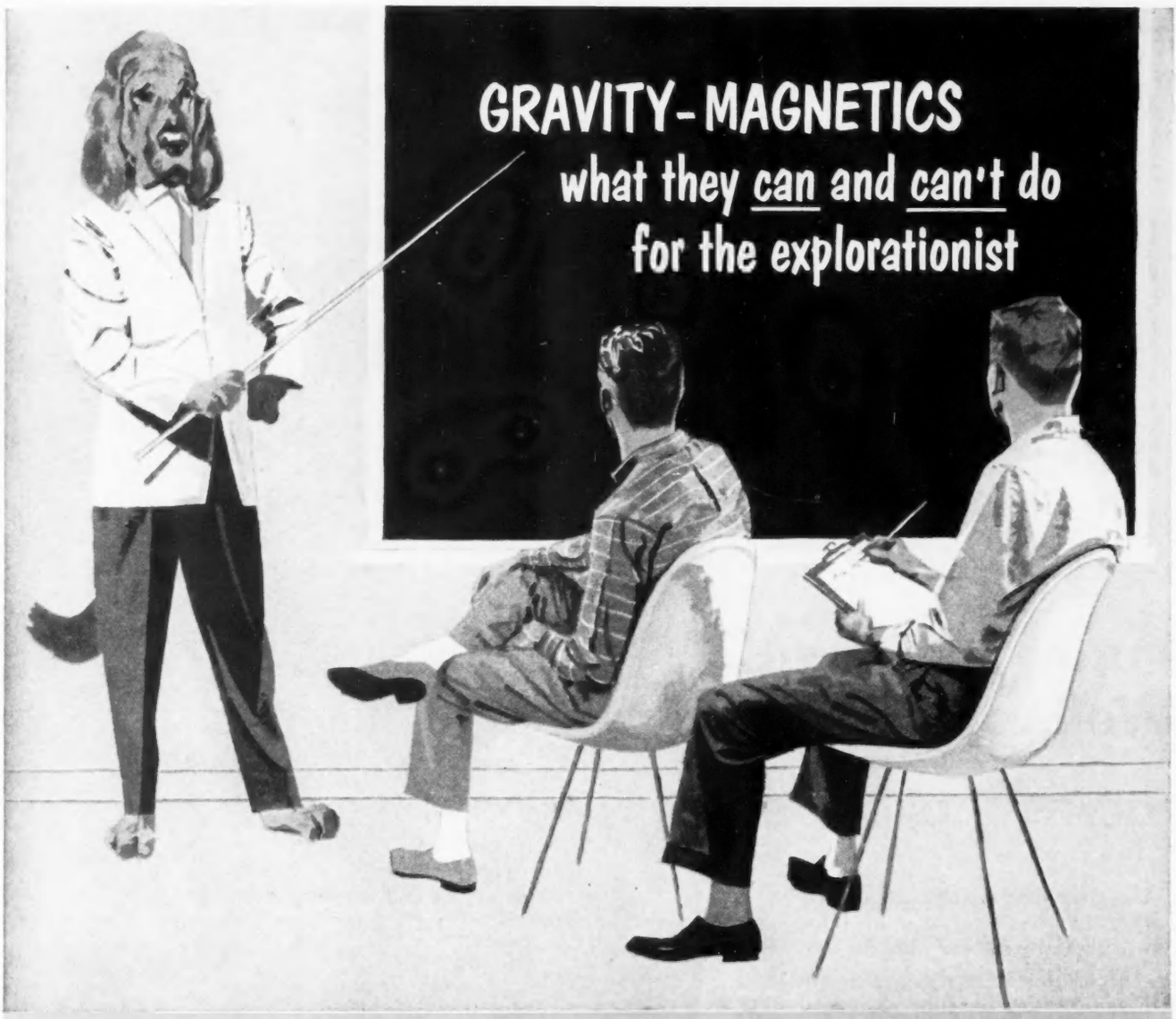
U.S. crude production of 6,809,000 bpd in June was 274,000 barrels or 3.9 percent under the 7,083,000 barrels of June last year. Production of natural gas liquids, however, was up 58,000 barrels or 6.7 percent to 923,000 bpd. Total imports of 1,622,000 bpd in June were down 280,000 barrels or 14.7 percent from the same month last year. Crude oil imports averaged 999,000 bpd, down 206,000 barrels or 17.1 percent. Imports of refined products averaged 623,000 bpd, a decrease of 74,000 barrels or 10.6 percent.

Crude runs to stills were larger than desirable in June. They averaged 8,090,000 bpd, an increase of 160,000 barrels over May and 103,000 barrels or 1.3 percent more than runs in June last year.

Stocks. Total stocks of all oils were increased during June by 14½ million barrels or 483,000 bpd. The large addition consisted of seasonally accumulating distillate fuel oil, residual fuel oil, and kerosine. Those additions were only partially offset by seasonal withdrawals of gasoline from storage and a limited reduction of crude oil stocks.

As compared with a year ago, stocks currently are generally at lower and more desirable levels. Stocks of all oils on June 30 this year totaled 787,600,000 barrels. That was 29 million barrels or 3.6 percent less than the 816,600,000 barrels held June 30, 1959. Crude oil stocks of 256,800,000 barrels were 15,700,000 barrels or 5.8 percent lower.

Distillate fuel oil stocks of 111,700,000 barrels were down 9,300,000 barrels or 7.7 percent. Residual fuel oil stocks of 41,200,000 barrels were off 14,300,000 barrels or 25.8 percent. Gasoline inventories of 201,700,000 barrels were, however, up 5,600,000 barrels or 2.9 percent. Kerosine stocks of 27,500,000 barrels were about the same as on June 30 last year. Stocks of all other oils combined totaled 148,700,000 barrels at midyear 1960, up 4,600,000 barrels or 3.2 percent.



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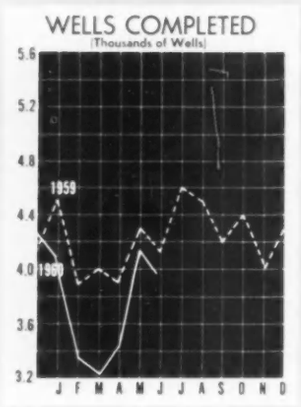
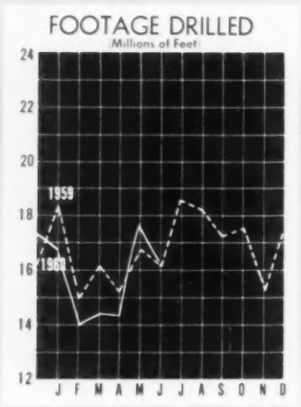
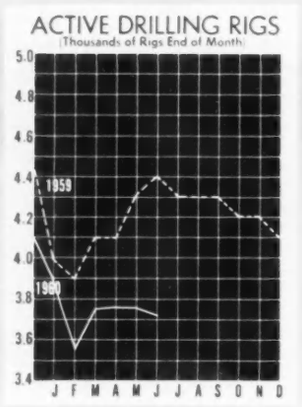
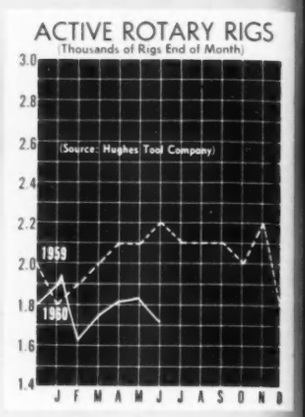
Drilling Activities.









Well completions down slightly

U.S. OPERATORS completed an average of 133 wells per day in June, down slightly from the May average of 134 wells per day.

Rigs operating on June 30 totaled 3,738, down 14 rigs from the end of May, and down 661 rigs or 15 percent from June 30, 1959. June wildcat activity totaled 753 wells, down 23 wells from May, and up 13 wells over the June 1959 total.

Footage drilled averaged 543,333 feet per day in June, down 6.9 percent from the 564,500 feet per day average in May. However, the total of 16.3 million feet drilled during the month of June was up slightly over the 16.1 million feet drilled during June 1959.

Trends for the first six months of 1959 are as follows:

- **New well completions:** 22,603—down 5.9 percent from the same 1959 period, with an extra day for leap year.
- **Footage drilled:** 95.1 million feet, down 4.4 percent.
- **Wildcats:** 4,432, down 2.6 percent.

Summary of U.S. Drilling Activity

ITEM	June 1960	May 1960	SIX MONTHS JANUARY-JUNE 1960	1959	% Diff.
New Wells Completed:					
Oil	1,880	2,036	10,906	12,377	—11.9
Distillate	62	72	416	413	+ 0.7
Gas	364	376	1,963	1,904	+ 3.1
Dry	1,578	1,589	8,834	8,772	+ 0.7
Service	110	85	484	557	—13.1
Total New Wells	**3,994**	**4,158**	**22,603**	**24,023**	**— 5.9**
Footage Drilled (Millions of Feet)	**16.3**	**17.5**	**95.1**	**99.5**	**— 4.4**

Summary of U.S. Wildcat Drilling

ITEM	June 1960	May 1960	SIX MONTHS JANUARY-JUNE 1960	1959	% Diff.
New Field Discoveries:					
Oil	38	39	265	341	—22.3
Distillate	6	7	44	50	—12.0
Gas	18	29	121	126	— 4.0
Total Discoveries	**62**	**75**	**430**	**517**	**—16.8**
Dry Wildcats	**691**	**701**	**4,002**	**4,035**	**— 0.8**
Total Wildcats	**753**	**776**	**4,432**	**4,552**	**— 2.6**
(Percent Productive)	8.2	9.7	9.7	11.4	.....
(Percent Dry)	91.8	90.3	90.3	88.6	.....

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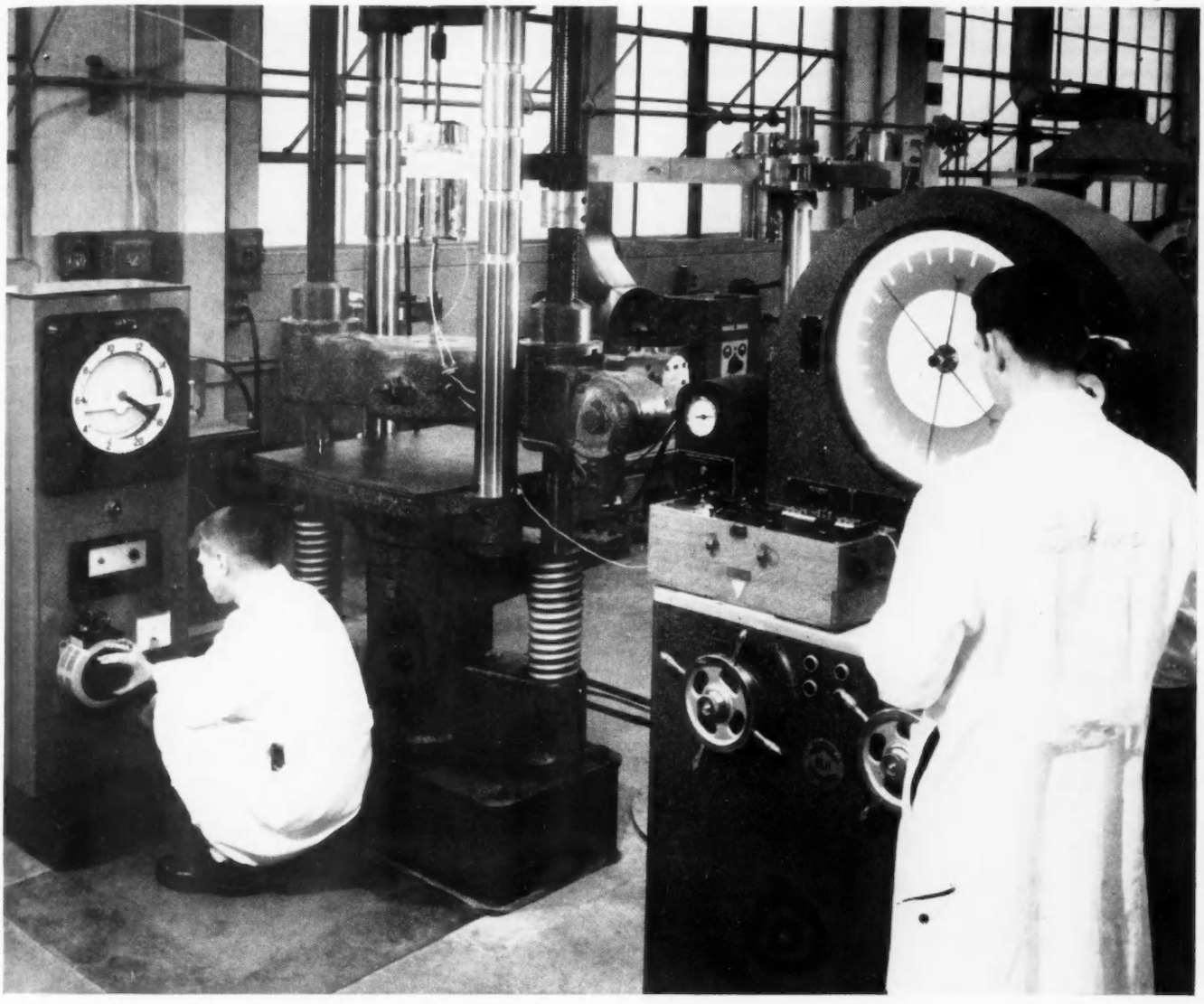
U.S. Drilling Activity in June and First Six Months, 1960-1959

STATE or DISTRICT	TOTAL NEW WELLS COMPLETED AND FOOTAGE DRILLED: DETAILS FOR JUNE, 1960 — Oil	Dist.	Gas	Dry	Service Wells	TOTAL NEW WELLS — June 1960	May 1960	June 1959	Total Footage June 1960	DETAILS FOR JANUARY-JUNE — NEW WELLS 1960	1959	Percent Diff.	FOOTAGE 1960	1959	WILDCAT DRILLING IN JUNE AND FIRST SIX MONTHS, 1960-1959: DETAILS FOR JUNE, 1960 — Oil	Dist.	Gas	Dry	Total Wildcats	DETAILS FOR JANUARY-JUNE — Oil	Dist.	Gas	Dry	TOTAL WILDCATS 1960	1959	DRILLING RIGS IN OPERATION (Rigging up, Drilling, Temp. Shut-down) June 30, 1960	May 31, 1960	June 30, 1959
Alabama	3			1		4	5	14	38,629	29	59	— 50.9	285,964	532,053				1	1				3	3	16	6	5	11
Alaska	2		1	2		5			61,283	8	4	+100.0	95,571	49,305						1			1	2	4	5	5	4
Arizona	1			8		9	1	5	19,972	13	6	+116.7	32,672	15,120				8	8				12	12	5	5	8	14
Arkansas	27		2	29		58	52	73	201,202	296	390	— 24.1	1,077,923	1,298,548			1	11	12	1	1	2	58	62	54	39	41	46
California	86		11	49	2	148	125	130	707,211	695	715	— 2.8	3,272,356	3,378,255	1		2	25	28	5		5	133	143	134	118	123	155
Colorado	6		9	23		38	34	54	190,840	301	336	— 10.4	1,587,901	1,771,412	2			17	19	10		4	135	149	184	50	54	58
Illinois	60		1	94		155	157	178	286,177	921	961	— 4.2	1,867,903	2,147,585	1			56	57	5			397	312	219	281	286	272
Indiana	24		1	60		85	95	83	111,998	455	400	+ 13.8	594,140	655,413				22	22	2			160	162	106	120	100	88
Kansas	185		16	188	18	407	496	369	1,434,276	2,485	2,258	+ 10.1	8,706,900	8,057,317	3		2	58	63	46		6	378	430	531	219	241	307
Kentucky	130		20	101	1	252	251	255	217,910	1,419	1,391	+ 2.0	1,202,260	1,276,417				6	6	5			24	29	44	125	140	157
Louisiana	128	20	33	150		331	378	299	2,439,535	1,648	1,759	— 6.3	13,437,932	13,894,123	3	5		54	62	15	10	4	227	256	237	325	397	408
North Louisiana	47		22	84		153	128	110	618,214	561	635	— 11.7	2,187,987	2,300,408	2			34	36	5		1	97	103	73	69	75	59
South Louisiana	81	20	11	66		178	250	189	1,821,321	1,087	1,124	— 3.3	11,249,945	11,593,715	1	5		20	26	10	10	3	130	153	164	256	232	349
* Gulf of Mexico	24	2		13		39	71	37	372,127	282	231	+ 22.1	2,870,824	2,327,466				3	3		1	1	17	19	18	53	57	62
Michigan	29		1	33		63	65	62	303,825	357	260	+ 37.3	1,309,682	757,535	3			16	19	8		1	95	104	60	110	112	91
Mississippi	13	1		30		44	51	53	459,434	357	310	+ 15.2	3,538,873	2,863,519				17	17	8			113	121	120	62	63	72
Missouri				3		3	1	3	9,969	9	6	+ 50.0	23,973	4,114										4	1	3	3
Montana	15			21		36	27	30	192,386	136	140	— 2.9	674,163	687,468				17	17	4		2	50	56	45	35	21	45
Nebraska	18			41		59	63	69	318,471	449	366	+ 22.7	2,573,489	2,178,803	2			24	26	11		1	175	187	169	41	36	47
New Mexico	94		38	50		182	142	116	830,969	907	798	+ 13.7	4,353,845	3,245,727	5		6	34	45	30		25	139	194	117	140	158	176
Southeast	74		4	42		120	98	64	585,402	615	449	+ 37.0	3,090,237	* 2,087,687	2		1	25	28	20		8	110	138	83	87	93	91
Northwest	20		34	8		62	44	52	245,567	292	349	— 16.3	1,263,608	1,158,040	3		5	9	17	10		17	29	56	34	53	65	85
New York	12		2	3	6	23	23	26	39,985	140	139	+ 0.7	241,365	240,630												25	25	25
North Dakota	11			11		22	24	47	137,598	146	230	— 36.5	910,952	1,419,932				4	4	2			29	31	45	22	23	31
Ohio	46		19	28		93	66	83	193,307	480	450	+ 6.7	1,164,567	1,229,660				3	3	2		3	18	23	13	171	156	223
Oklahoma	198	10	25	144	59	436	456	420	1,538,485	2,255	3,015	— 25.2	8,945,900	10,533,498	3		1	43	47	22	4	20	202	248	403	397	395	498
Pennsylvania	23		27	7	19	76	71	48	240,502	407	286	+ 42.3	1,215,123	939,108								3	6	9	8	215	213	152
South Dakota				1		1		1	8,526	15	7	+114.3	109,724	31,263									5	5	4	2	1	1
Tennessee	2			3		5	7	11	3,964	39	61	— 36.1	31,026	61,125						1		2	20	24	20	25	20	25
Texas	684	31	97	431	4	1,247	1,415	1,327	5,440,030	7,641	8,791	— 13.1	33,774,117	38,533,271	12	1	4	240	257	76	28	35	1,511	1,650	1,839	852	898	1,137
Dist. 1: South Central	26	1	4	32		63	80	67	191,484	489	497	— 1.6	1,402,762	1,271,611	1			23	24	3			146	149	153	33	32	40
Dist. 2: Middle Gulf	27	14	9	26		76	74	73	501,395	391	398	— 1.8	2,608,771	2,389,811	1	1		16	18	3	9	4	104	120	139	52	56	57
Dist. 3: Upper Gulf	45	2	5	27		79	104	96	522,219	567	587	— 3.4	4,036,539	4,249,779				19	19	3	7	2	127	139	128	102	112	120
* Gulf of Mexico							1			3	1	+200.0	24,703	11,005									1	1	1	1	2	
Dist. 4: Lower Gulf-S.W.	24	11	10	47		92	100	112	507,412	524	665	— 21.2	2,951,738	3,609,056	1		2	31	34	6	9	11	161	187	209	77	65	93
* Gulf of Mexico																												
Dist. 5: East Central	4		3	12		19	13	9	108,113	100	62	+ 61.3	487,692	342,576				9	9	1	1	2	52	56	29	9	13	12
Dist. 6: Northeast	42		3	35		80	74	78	413,487	410	399	+ 2.8	2,235,235	2,236,315				22	22	3	2	1	83	89	83	51	69	62
Dist. 7-B: North Central	100		10	74		184	246	199	560,054	1,160	1,222	— 5.1	3,461,010	3,909,133	4			38	42	24		7	322	353	396	94	81	103
Dist. 7-C: West Central	47		5	26		78	88	68	330,348	397	353	+ 12.5	1,649,495	1,464,397	2			16	18	7		3	99	109	104	56	75	75
Dist. 8: West	181		11	40	4	236	246	305	1,243,778	1,577	2,342	— 32.7	8,479,107	11,559,129	2		2	24	28	22		4	171	197	258	189	194	296
Dist. 9: North	132		7	85		224	304	228	559,425	1,447	1,714	— 15.6	3,815,832	4,897,752	1			30	31	4			196	200	266	122	127	175
Dist. 10: Panhandle	56	3	30	27		116	86	92	502,315	579	552	+ 4.9	2,645,936	2,603,412				12	12			1	50	51	74	67	74	103
Utah	11		4	5		20	17	30	116,413	111	161	— 31.1	614,415	907,618			2	4	6	1		4	39	44	39	24	32	48
Washington										2			12,082										2	2				
West Virginia	27		55	16		98	65	61	230,023	419	363	+ 15.4	1,108,014	932,259												225	195	183
Wyoming	45		2	43		91	70	86	475,629	452	355	+ 27.3	2,296,553	1,864,568	3			28	31	10	1	4	150	165	128	94	86	113
Others				3	1	3	1	6	9,422	11	6	+ 83.3	62,219	29,090				3	3				10	10	4	4	5	9
Total United States	1,880	62	364	1,578	110	3,994	4,158	3,939	16,257,971	22,603	24,023	— 5.9	95,121,604	99,534,736	38	6	18	691	753	265	44	121	4,002	4,432	4,552	3,738	3,752	4,399
Total Western Canada	103		22	46		171	129	225	766,315	1,108	1,234	— 10.2	6,099,877	6,121,611												169	151	214

* Gulf of Mexico wells are included in their respective district totals.



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They're working with the hot tensile testing machine in The Timken Company's modern Metallurgical Research Center—testing steel under increasing loads (as high as 60 tons) at high temperature, until rupture occurs. It's just one way we pre-test steels to determine their performance in high temperature applications. Another assurance that you will get Timken® seamless steel pressure tubing having just the right analysis for your job. The one that will give you the best possible tube life per dollar.

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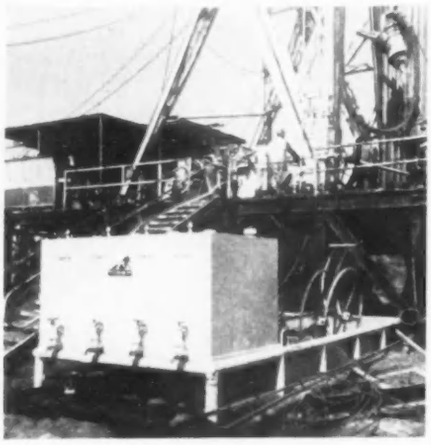
Practical Operating Hints

These How-To-Do-It Ideas Can Save You Money

$10 is paid for each illustrated acceptable contribution. Mail to The Editor, WORLD OIL, P. O. Box 2608, Houston 1, Texas



Lubricant Container Forms Part of Tool Bin

Lubricant containers are mounted on the end of the tool bin which carries the spare equipment used around the rig. This places the lubricants at a spot handy to all parts of the rig while the outlets are high enough to clear the containers used for transferring the lubricants.

The entire unit is easily transferred from one location to another along with the rigs spare tools.

Portable Pump Serves Several Tank Batteries

This portable circulating pump trailer was constructed from junk material in the field. Since the operator had several tank batteries in the immediate area, he found that it was more economical to buy one portable utility circulating pump than install one at each battery.

Connections are provided at each location so the pump may be rolled into position and "unioned" up in minutes. Whenever the pump is required at a different battery, the lease pumper simply knocks the suction and discharge hoses loose, ties the pump trailer to the lease truck and moves it to the required location.

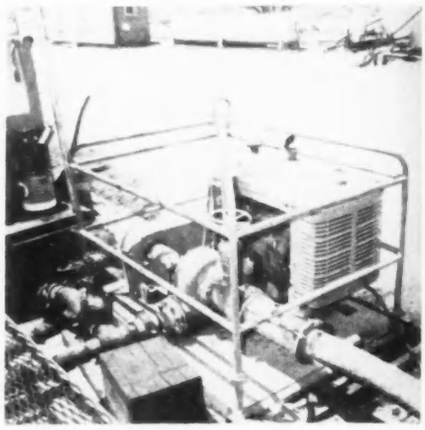
Louver-Like Rig Doors Aid to Weather Control

Rigs must be equipped for drilling in varied climatic conditions. These louver-like doors were equipped with hinges, and may be opened or closed, according to the temperature of the area of operations.

The entire rig floor, except for the derrick floor, is enclosed with a metal covering and windows were necessary to attain proper ventilating conditions.

Permanent Knowledge Box Made From Scrap Pipe

A small quantity of junk pipe and scrap tank steel can be used to make a weather proof tank battery knowledge box as shown. Orifice meter charts, run tickets, pump running time sheets, messages, etc., are secure in all kinds of weather.



Unitize Washdown Pump For Cleaning Operations

This pump unit has been mounted on a skid made of a diamond plating material and 2½-inch pipes. The guard railing is made of 1¼-inch pipe.

The vertical guard rails are connected to the base with an ordinary union coupling, thus enabling quick removal of the entire guard from the base if necessary. An eyelet is placed in the center of the guard so as to pick up the entire unit and move it from one location to another.

Equip Lease Truck To Haul Pump Barrels

This operator has installed a headache rack and tail-gate rack made of 2-inch pump barrels on the lease truck. Each rack is equipped with two loops made of ½-inch sucker rods. By using two small 4-foot-long chains and two boomers, long pieces of pipe or pump barrels can be transported safely by lease pick-up truck.

Smith ROCK BITS

TOPS ON BOTTOM

MORE FOOTAGE

FASTER PENETRATION

FULL-GAGE HOLE

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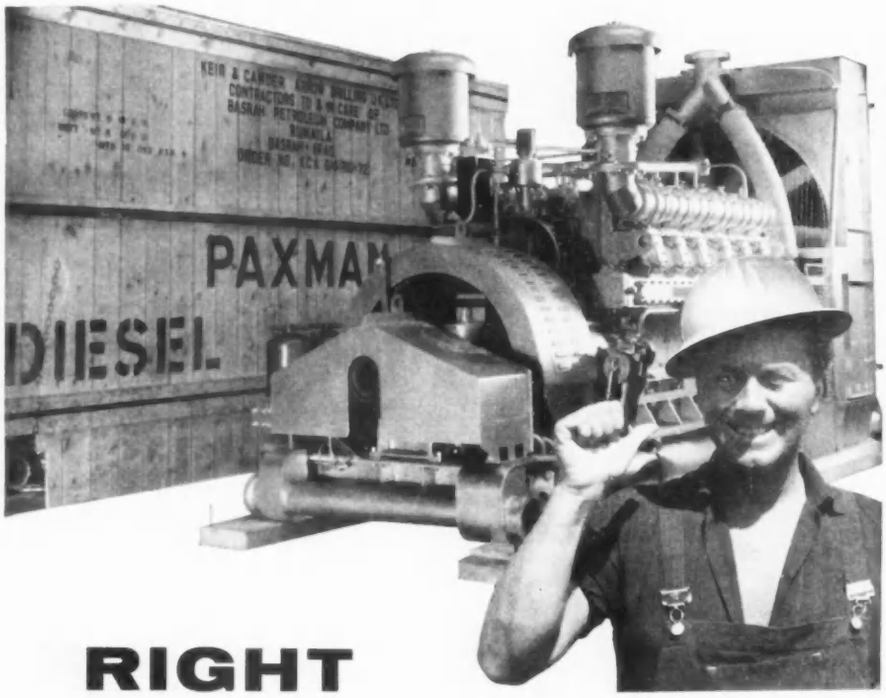
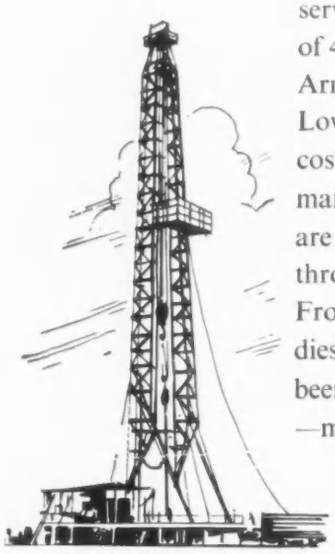


RIGHT ON SCHEDULE

You're looking at the business end of a 60-day delivery promise. Right on time, delivered on schedule.

And that's only one side of Paxman power service. Here is a Paxman Drilpak 400F Set of 430 s.h.p. One of seven for Keir and Cawder Arrow Drilling (U.K.) Ltd.—reliability itself. Low priced, lightweight to cut freight costs, easily accessible for simple maintenance, these high powered diesels are backed by a *real* after-sales service through a world-wide agency network. From Basrah to Maracaibo, the Paxman diesel goes down better than a can of cold beer. For unfailing power at the lowest cost —make it 'Paxman', oilman!



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7" AND 9¾" BORE DIESELS, RANGING FROM 90 TO 2310 H.P.

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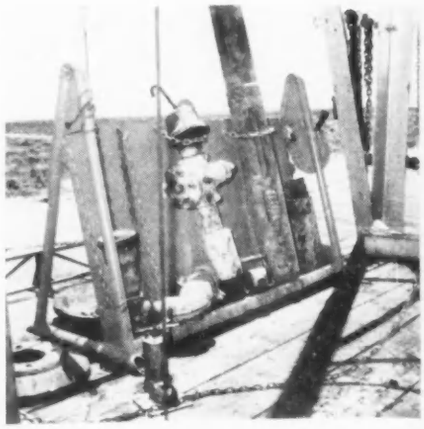
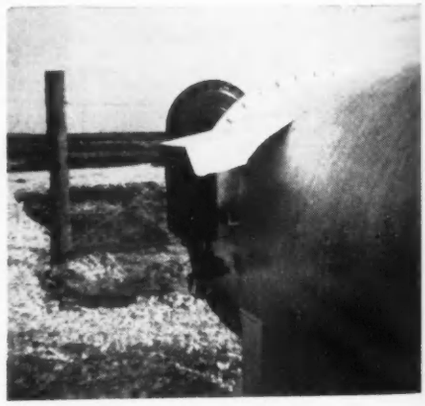


Tilted Structure Used For Storing Subs at Rig

A slotted-tilt rack is used to properly store subs, reamer bodies, etc., on the derrick floor. The rack is rigidly built using 2-inch piping material as the framework. A ¼-inch piece of steel plate is used for the tools to rest against.

In order that the miscellaneous items are rigidly held in place, a chain is attached to the steel plate and then rewrapped around the object. A base is attached to the entire rack which means that the entire unit may be removed intact.



Make Protector For Regulator Pilot

Pneumatic control pilots for diaphragm operated chokes often become damaged when maintenance work is required on the choke or line heater. This operator has solved the problem by moving the pilot to the side of the line heater and protecting it with an overhead piece of sheet metal. As shown, the pilot is completely away from the choke, thus removing it from the work area. The pilot is mounted on a short length of angle iron. The overhead protector serves to keep rain from blowing into the pilot when opened.

Post Sign to Warn Of Drillstem Tests

Safety around a rig must always be practiced. Any signs reminding the rig personnel and others of unusual practices are very important. Therefore, drillstem tests should be made known to all personnel.

Here is a sign illustrating that a drillstem test is underway and precautionary measures should be followed. The lower portion of the sign can be used for any additional remarks, messages, operating company name, well name location, etc.

Use Discarded Barrel To Spot-Check Production

When short, accurate well tests are required because of new equipment testing, secondaary recovery operations, etc., it is often impossible to obtain these checks through regular test facilities. This operator has devised the simple barrel test as a means of spot-checking production from a particular well. The flow line at the well is tapped and a tee and riser with valve are installed as shown. A stop-watch is used to time the interval required to fill the drum to the 42-gallon mark. This interval of time in minutes then is divided into 1,440. The answer is the daily production rate.

Use Old Tank Steps To Reach Chemical Pump

Discarded tank-steps have many uses, one of which is illustrated here. These steps provide access to the chemical pump mounted on the beam pumping unit.

Patent Pending

No-Wall-Stick Drill Collars

effectively reduce sticking of drill collars. . .

Please write Houston office for descriptive brochure and price schedules

No-Wall-Stick Drill Collars

The surface area of these drill collars has been changed to reduce wall contact area by more than 40%. Weight loss of the drill collar is only about 4%. Reduction of 40% in contact area results in a proportionate decrease in the total sticking force due to differential pressure of 40%. This design also gives a section of pressure equalization each foot along the body of the drill collar.

Three sizes (6", 4¾", 4⅛") of NO-WALL-STICK DRILL COLLARS are available on a rental basis in the Texas and Louisiana Gulf Coast area. Rental price of these NO-WALL-STICK DRILL COLLARS is very competitive to conventional drill collars run with stabilizers.

Any new or used drill collars, regardless of size, owned by Drilling Contractors or Oil Companies may be converted to NO-WALL-STICK DRILL COLLARS for a fixed conversion charge.

NO-WALL-STICK DRILL COLLARS offer far more protection from wall sticking in high angle holes or holes which have shale wash outs than drill collar strings using stabilizers.

NO-WALL-STICK DRILL COLLARS will not ball up, will not peel off wall cake, and may be sealed off by a Hydril type blow out preventor at any point.

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CE 4-4607

No-Wall-Stick Drill Collars may be handled through your local rental tool company.

Pipe Bin Makes Stand For Tool Box and Tanks

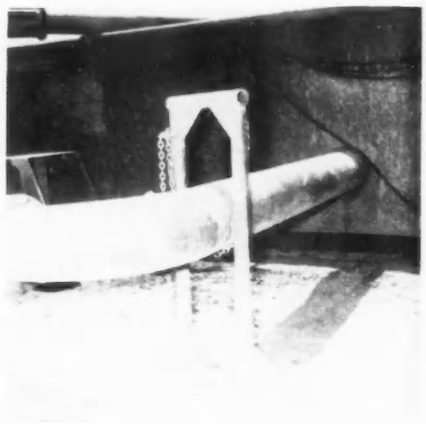
On rigs that are continually on the move, a good place to have the water and fuel tanks located is across the end of the pipe bin. This puts them high enough so that water and fuel will gravitate to all parts of the rig and makes them easy to unload and load. This also saves moving an extra stand from rig to rig to hold up the tanks.

The other end of the pipe rack has a bin for small hand tools.

Support for Mud Piping Has Built-in Flexibility

This mud support is light, less bulky and can be easily adjusted to any desired height.

The support is made of 1½ and 2-inch pipe as the upright and horizontal members. One end of the chain is welded to the cross member of the support while the other end is fastened to the upright portion of the support, forming a cradle for the mud line.



For added rigidity, gusset plates and footings are made of ¼-inch steel plates and welded to the support members.

RUGGED

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This JENSEN COMBINATION JACK is economical to buy, more economical to operate. Get the complete story by dropping a card or letter to us at Coffeyville.

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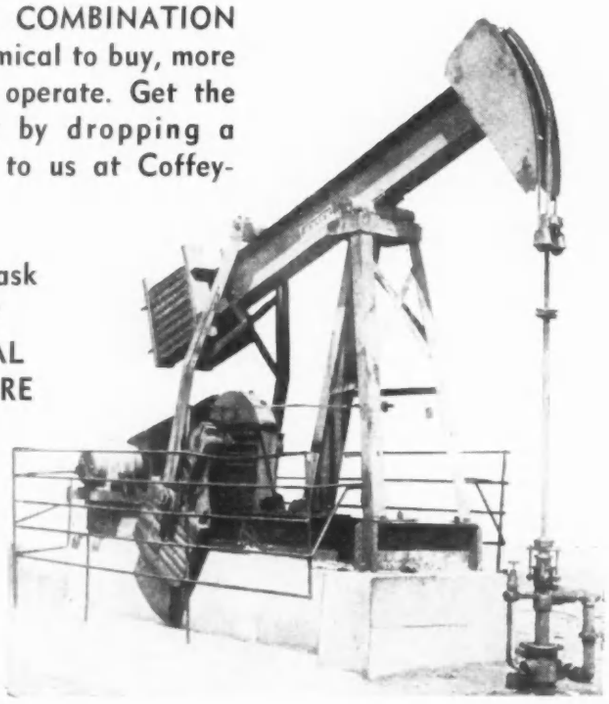

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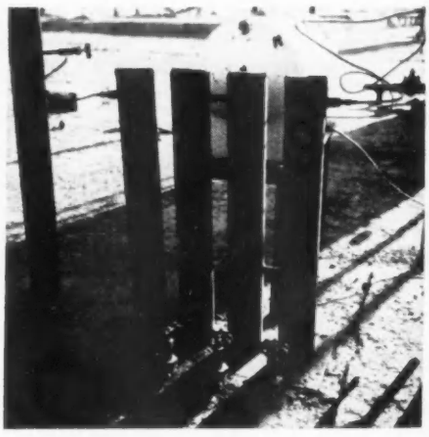
JENSEN JACKS



Quadruple Scrubber Yields Dry Supply Gas

This four-barrel drip does an excellent job of providing liquid free supply gas to pneumatic operated controls on this tank battery. Copper tubing is used to tie the scrubber into separator gas line shown at far left.

As wet gas enters the scrubber, it must travel to the bottom of the first barrel, pass through a ½-inch nipple to the second, travel to the top of the second barrel and then pass through another ½-inch nipple to the third barrel.

The procedure is repeated in this fashion until ready-to-use dry supply gas is discharged at the top of the fourth scrubber barrel on the right. All barrels are made of 4-inch line pipe and can be field constructed with a minimum of welding time required.

CURRENT OIL INDUSTRY FISHING TECHNIQUES AND TOOLS

1. Cased Hole

By Weldon Medders, Chief Engineer
Hunt Tool Co., Houston

D. U. (Doc) Skinner, Sales and Service Representative
Houston Oil Field Material Co., Houston

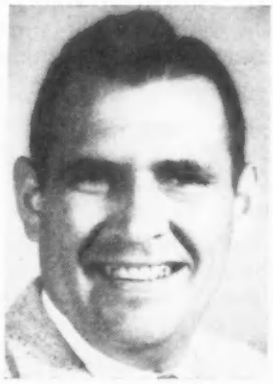
THE OIL INDUSTRY is facing ever increasing costs in its efforts to find additional crude oil reserves. These costs vary from tangible to intangible expenditures.

One example of intangable costs which can unbalance budget programs is the expenditure involved in fishing operations in both drilling and producing. A fish is any foreign object existing below the surface in either a cased or open hole. Since costs of removing a fish can be extremely high, means of decreasing such costs deserve extensive and detailed analysis.

Although there is no available yardstick in comparing fishing costs to over-all oil industry expenses, they exert a major influence on the cost-profit picture.

Because fishing techniques and tools undergo continuing improvement and development, it is imperative that operating personnel be informed of recent developments.

In view of this problem, the latest fishing practices encompassing these two fields of operation will be presented in this Engineering Practices Manual.



This manual has been written to:

► Re-acquaint supervisory personnel with current methods used in the recovery of foreign objects (fish) from open and cased holes.

► Assist in the training of new engineers in techniques and tools used in oil industry fishing problems.

While the techniques of recovering a fish may vary from one operator to another and while it is impossible to describe every known fishing method, this manual contains many of the proven techniques currently accepted by industry.

Jack F. Earl

The Authors

Weldon Medders is chief engineer for the Hunt Tool Company. He has had 19 years experience in the design and development of tools and equipment for the oil industry. After two years with the Reed Roller Bit Company as tool designer, he joined the engineering staff of HOMCO where he served successively as project engineer, chief engineer, and in 1957 became Director of Engineering, Research and Development. In 1959 he joined Hunt as research engineer. He attended The University of Texas.

D. U. (Doc) Skinner attended San Marcos Baptist Academy at San Marcos, Texas and following his graduation in 1916, was actively engaged in Naval assignments until 1919. From 1922 until 1924, he was affiliated with the Humphrey Oil Company in the Mexia field. Between 1924 and 1937, he was associated with pipe line, production and drilling operations. In 1935 he joined the Stone Oil Tool Company as a fishing tool operator. Continuing in this profession, he joined Houston Oil Field Material Company in 1937. Except for assignment as vice president and general manager of HOMCO Service, Inc.,-Venezuela, S. A., he has been in active contact with extensive fishing operations, in the United States. Currently, he is a sales and service representative for HOMCO.

Contributors

J. B. (Jug) Davis, Sales Manager
Brown Oil Tools, Houston

George Roach, Assistant to Director of
North American Sales
CAMCO Inc., Houston

Comments

"These step-by-step descriptions of the various service operations should bring about better understanding and cooperation among drilling and service company personnel. The article should be especially helpful to operators in foreign countries where service technicians are not always readily available."

Z. C. Ambrose
Executive Vice President
HOMCO

"To my knowledge this the first complete treatise on fishing operations to be published. This manual is a valuable addition to the library of anyone connected with the drilling phase of our industry."

J. B. (Jug) Davis
Sales Manager
Brown Oil Tools, Inc.

"In presenting a practical detailed discussion of the techniques of recovery, this manual will prove of real assistance not only to operators and engineers, but also to students and newcomers to the oil business."

A. B. Foreman
Manager, Fishing Tool Division
Hunt Tool Co.

"A valuable working tool for use in the oil industry."

B. M. Scivally
Manager of Fishing Tools Division
Wilson Supply Co.

"Fishing successfully in oil wells is an art requiring knowledge of both tools and techniques. Paralleling the growth of the oil industry over the years many standard fishing tools and fishing procedures have been developed. The oil industry has long needed a reference manual of these developments. When equipment becomes lost or stuck in a hole, it should be recovered as soon as possible. The longer a fish remains in the hole, the more difficult it is to remove it. This reference manual will aid greatly in the selection of proper tools and the application of proper fishing techniques needed to expedite recovery."

Dean W. Osmun
Vice President and General Manager
Bowen Itco, Inc.

"A very useful means for training new engineers or college personnel in the oil industry. A manual of this type is very beneficial for acquainting supervisory personnel with different techniques and tools used in fishing operations."

T. B. O'Brien
Head, Drilling Section, Technical Services
Gulf Oil Corp.

"A very useful manual to acquaint new personnel in the drilling industry with up-to-date fishing techniques and tools."

Paul Schaffer
Chief Engineer
A. W. Thompson, Inc.

CASED HOLE FISHING EQUIPMENT AND TECHNIQUES

Fishing in cased holes entails the removal of any object existing in the hole after running the casing string. Discussed in this section will be:

I. Recovery of liners

A. Liner set in open hole with upper end in casing.

B. Liner set in open hole with upper end in casing-4-inch OD setting head.

C. Five and one-half-inch OD liner set in open hole with upper end in 7-inch, 26-pound casing.

D. Liner set in open hole with upper end in casing and a canvas packer without holddown slips has been used to seal the annulus between the top of the liner and the casing. Also, the liner is equipped with a slotted screen wrapped with stainless steel wire.

E. Same as D above except that liner-packer with externally set holddown slips and a rubber packing element has been used.

F. Same as E except that a liner packer with internally set holddown slips and a canvas packing element has been used.

G. Same as F except that a packer with unrestricted bore and synthetic rubber packing has been used.

H. Short string of liner is set off bottom by means of a liner hanger and is stuck inside and out.

I. A 240-foot liner has been cemented beneath the intermediate string, on the outside from top to bottom and on the inside from float shoe to landing collar. The liner which has remained in the hole for 15 years, has sanded up and possibly has been corroded. Until the sanding condition occurred, the well was a good producer.

II. Recovery of production packers

1. **Hook wall packers**

A. Control head circulating packer at 5,500 feet in 5½-inch, 20-pound casing. One joint of 2-inch non-perforated production tubing below packer. Tubing string has been washed over and backed off down to packer, leaving one joint of 2-inch production tubing with 3⅛-inch OD collar above the packer.

B. Seven-inch mechanical packer at 9,600 feet has become sanded up and corroded. The stem cannot be rotated to the right to release the seals and slips. One joint of 2½-inch tubing has been left above the packer. A 15-foot perforated nipple below the packer is stuck tightly.

C. Full opening hydraulic set packer with built in torque jar and safety joint is stuck in 7-inch, 29-pound casing at 7,800 feet. Two and one-half-inch tubing has been parted with an acid cutter above the packer leaving a 20-foot neck for fishing purposes. Stem of packer cannot be rotated or reciprocated to release, indicating that the perforated tail pipe is stuck tightly. The packer is completely drillable.

D. Five an one-half-inch multiple ring control head and circulating packer with J release and dove-tail slips is stuck so that the mandrel cannot be rotated or reciprocated. One joint of 2-inch is left above the packer. 30-foot tail pipe below packer is stuck tightly.

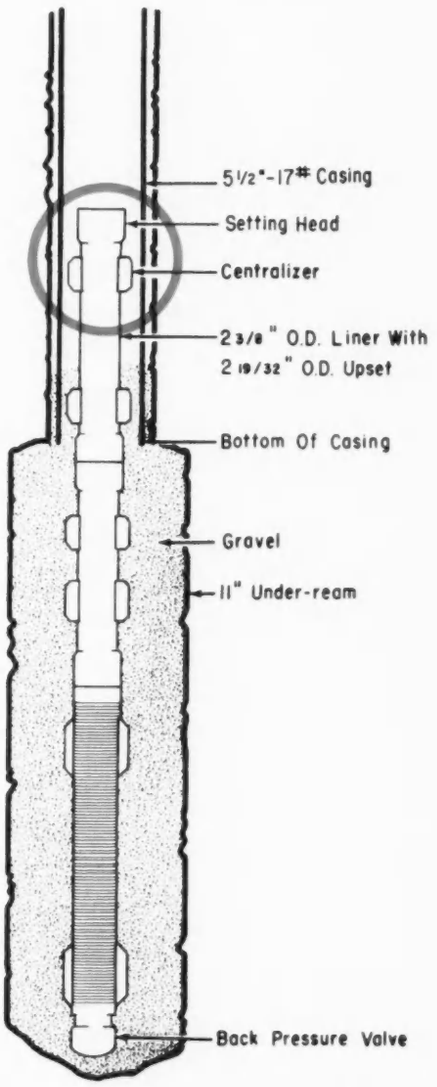


Figure 1—Liner set in open hole with upper end in casing.

2. **Permanent production packers (single)**

Permanent production packer is stuck so that the production string cannot be withdrawn from the well. A 30-foot production tube with a 20-foot perforated extension is stuck tightly below the packer. One joint of tubing is left above the packer for fishing purposes.

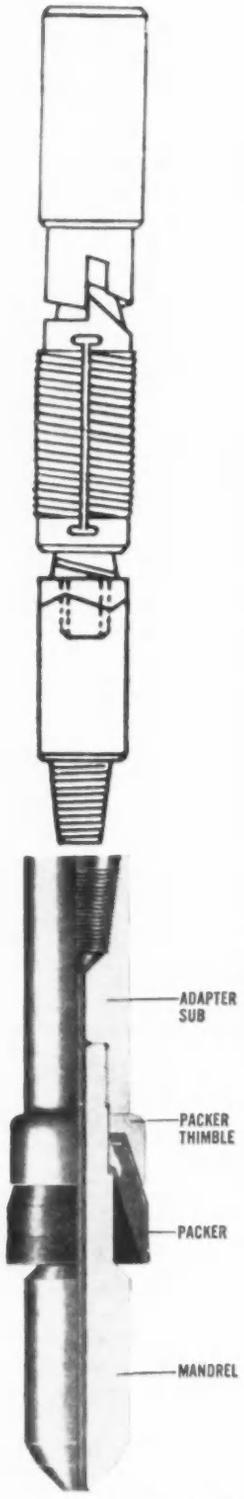
3. **Multiple production packers**

III. Recovery of tubing

A. When the tubing is weakened by corrosion, erosion, or abrasion and is pulled in two while trying to retrieve packer or pipe.

B. Where tubing is stuck due to a mud or sanding condition.

C. When the down-hole equipment is larger in diameter than the tubing (gas lift mandrels) and the



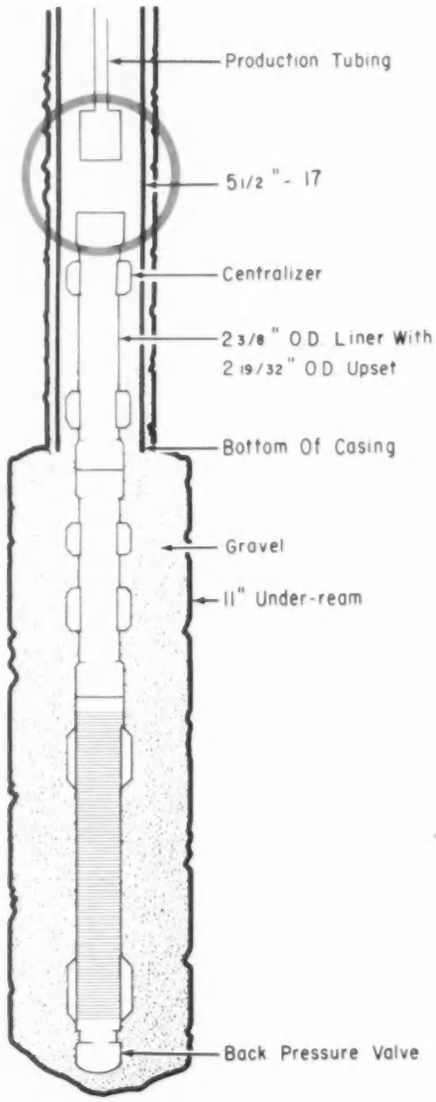


FIGURE 2—The releasing spear and pack-off assembly is shown going in the hole.

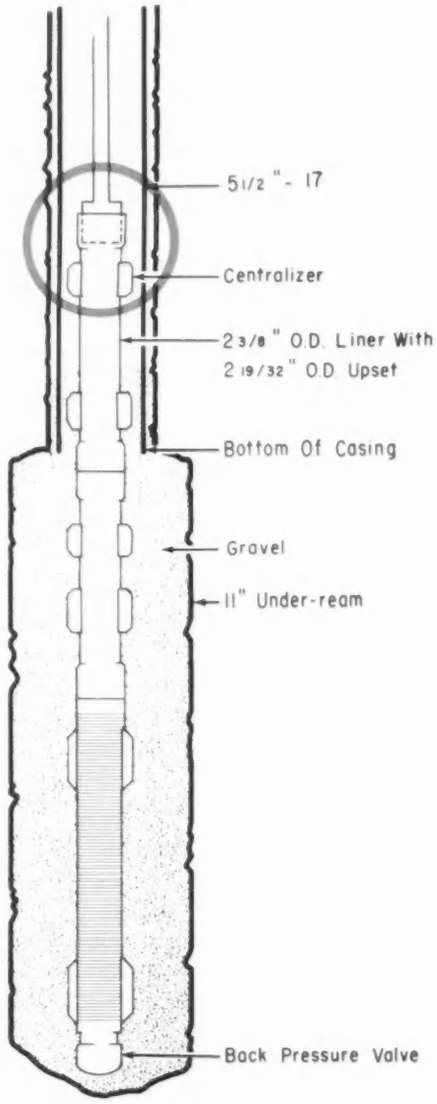


FIGURE 2A—An upward pressure causes the releasing spear slips to expand and catch the fish.

tubing or bottom-hole equipment has failed due to erosion, corrosion or abrasion.

D. Collapsed casing which causes an obstruction and prevents pulling tubing.

IV. Recovery of rods

V. Recovery of wireline tools

RECOVERY OF LINERS

Case A. Liner set in open hole with upper end in casing (Figure 1).

1. Hookup, bottom to top. Back-pressure valve, one joint of screen with centralizers, 2 joints of blank with flush head in casing. Fluid level of well several hundred feet above top of liner. Bottom production tubing extending slightly below fluid level. Packer not used.

2. Hole conditions—straight hole. Loose, unconsolidated fine sand with gravel packing extending up into casing. Fine sand has penetrated gravel and stuck liner all the way to the top; sand also has penetrated screen and filled up inside of liner. One joint of liner is contained and centralized in casing, the other joint and screen are in open hole which has been underreamed to 11-inch diameter for better gravel packing conditions.

3. Pipe sizes

Casing: 5½-inch—17 pound
Screen: 2⅜-inch OD x $2^{19}/_{32}$ OD upset
Liner: 2⅜-inch OD with $2^{19}/_{32}$ OD upset
Centralizers: 2 per joint
Production tubing: 2⅜-inch OD collared.

4. Fishing operations

► **First Operation:** After removing production tubing from well, make up 4 joints of $1^{13}/_{16}$-OD flush joint little inch pipe with diamond point bit on bottom. Clean and dope threads. Make up pipe manually with 24-inch tongs

and hammer up. Make up 2-inch production tubing above the little inch. Rotate occasionally while going in hole. When bit approaches top of fish, adjust pump pressure for jetting action and circulate and clean top of fish thoroughly before trying to insert bit into liner.

Rotate pipe slowly by hand and enter liner. Using water or light mud and sufficient pump volume for high velocity jetting action at bit, wash and jet sand out of liner and screen. Do not rotate pipe, since the little inch or macaroni string will wind up and possibly twist off before any excessive torque can be detected at the surface.

Increased fluid velocity may be used to break through stubborn streaks. After washing to bottom, pull out of hole.

► **Second operation.** Make up string bottom to top as follows:

- Packoff consisting of bull-nosed mandrel, packer thimble and packer to seal in 2.0 ID
- 2⅜-inch OD tubing spear with approximately 3⅛-inch OD shoulder stop and 1⅞-inch OD mandrel with slips to catch 2.0 ID
- 2⅞-inch OD bumper jars, 3¾-inch OD hex or spline-driver, with 15-inch to 20-inch stroke
- 2⅞-inch OD hydraulic jars, 3¾-inch OD, with 10-inch to 15-inch stroke, two or three 3½-inch OD drill collars if available. Using power tongs, make up enough 2⅜-inch OD production tubing to complete the string.

Lower the string until the spear packoff is slightly above the top of the liner. Start the pumps, circulate and condition well with fluid until the top of the fish is completely free of all sand and foreign matter.

After cleaning sufficiently, stop circulating and lower the packoff and spear assembly into top of the fish, thereby forming an effectiv seal between the liner and the tubing of fishing string. As a general rule, unless rotation is necessary to effect entry into fish, do *not* rotate the pipe. The spear is run into the hole in the catch position and right hand rotation when entering the fish will cause the spear to release, making setting more difficult.

When the shoulder stop or bumper ring on the spear contacts the upper end of the liner, simply pick up the string. This will cause the slips to expand and set in liner (Figure 2A).

If the spear has released prematurely due to right hand rotation while going in the hole and before entering the fish, it then is necessary to reset the spear in the liner.

This is done as follows: Rotate spear one full turn to the left. This movement places the slips of the spear in the catch position so they are in slidable relationship with the slip mandrel.

Pick the string up slowly. As the slip mandrel of the spear moves upward, the slip cage remains stationary, being held in position by springs or wiper blocks which are in frictional engagement with the inner walls of the liner. Continued upward movement of the slip mandrel expands the slips outwardly, wedging and locking these members tightly in the liner.

Take a strain of several thousand pounds above string weight to be sure that the spear is securely caught in the liner. In this position, pull up and trip jars into the expanded position. Build up maximum allowable pressure in the liner and screen and, with additional upstrain, attempt to pull and pump the fish loose. If this is unsuccessful, maintain pump pressure and with hydraulic jars try to jar the fish loose with repeated blows.

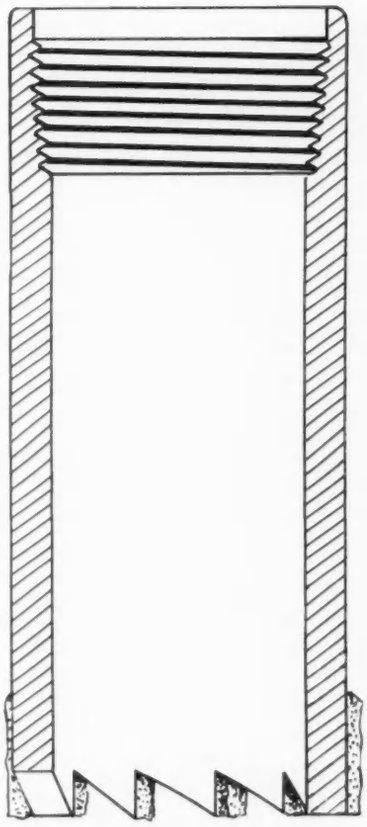


FIGURE 3—A mill-type shoe with conventional hard facing used to mill aluminum or bronze type centralizers.

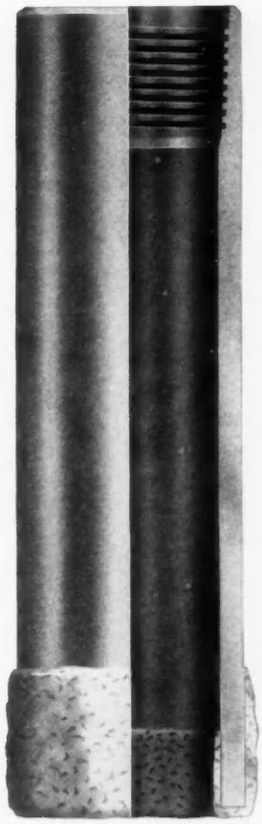


FIGURE 4—A carbide burning shoe used to mill centralizers made of steel.

For 2-inch tubing, the jars would be set to trip at 10—15,000 pounds. This pull, together with the inertia from the drill collars will result in a considerable impact.

► **Third operation.** If all these operations fail, a washover operation is the most economical approach to recovery. Another possibility is an operation involving a hydraulic pulling tool; however, since the liner is obviously stuck tightly, this method should not be attempted because of the risk.

In the first place, economic considerations dictate use of simple washover equipment as opposed to pull tool, safety joint, drain sub, spear, jars and sometimes a cutting tool. Second, the liner may part (it has been in the hole for an extended period) when exposed to the powerful forces exerted by the hydraulic pulling equipment. This would complicate rather than alleviate further fishing operations.

Accordingly, make up string as follows:

- Washover rotary shoe
- Four joints of 4-inch, 11.60 lb. washpipe
- Safety joints
- Two-inch production tubing to complete the string.

The design of the rotary shoe is dictated by the type of centralizers used on the fish. If the centralizers are

FIGURE 5—A drive bushing is sometimes used in place of the kelly while washing over.

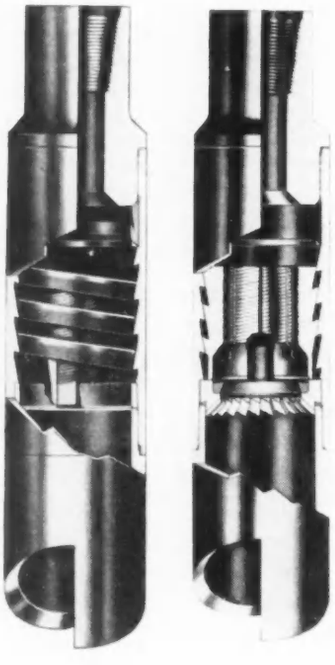


FIGURE 6—A standard catch overshot is run where an ample amount of space is available above centralizer.

made of aluminum or bronze, the following mill type shoe, with conventional hard facing (Figure 3) is used:

OD of body - 4-inch

OD of ribs - 4¼-inch

ID of body - 3.428

ID of cutting teeth - 3.428-Min.

Number of cutting teeth - 22 to 24 Fine.

Cut milling teeth about ½-inch deep with either 0° or slightly negative rake angle. Cutting teeth are hard-faced with tube metal on bottom and inside only. To prevent damage to the casing, no cutting metal is present on the OD of the shoe. Four smooth ribs about ½-inch and 1½-inches long are equally spaced around the circumference of the shoe. In addition to centralization, these ribs provide better circulation and less friction.

The fine-cut mill-type teeth provide a smoth cutting action on the centralizers, and yet provide for adequate circulation through the valleys of the teeth. In this case, the large conventional teeth commonly used on formation type rotary shoes would have a tendency to hang up on the centralizers, creating excessive torque and greatly increasing the danger of twist-off.

If the centralizers are made of steel, a carbide burning shoe (Figure 4) is recommended for best results.

The physical dimensions of this shoe are essentially the same as above, the principal difference being that a matrix interspersed with jagged carbide particles is used for cutting purposes rather than conventional tube metal. The scalloped, or "ocean-wave," design permits maximum circulation and prevents the shoe from being pumped off bottom in a heavy washover operation.

This design is also good for cutting metal which is imbedded in the formation. The shoe, works equally well on bronze or aluminum. While penetration rates of carbide shoes are three to four times faster than those of conventional shoes, the product cost is several times higher and unless considerable rig time is saved, the higher cost is not offset.

In workover operations, considered here, there generally is not enough time saved to justify the cost of a carbide shoe for cutting bronze or aluminum. In most cases, the penetration rate is limited by size and type of rig and by pump capacity factors which will not be altered by the type rotary shoe used. Hence, for cutting soft materials (bronze and aluminum), a conventional shoe is recommeded.

Cost of the carbide shoe would be justified in the case of steel centralizers, since use of a conventionl shoe would retard the penetration rate and probably would require two trips rather than one. Thus, several hundred dollars worth of rig time would be required.

If centralizer material is unknown, a carbide shoe should be used. The wash string is lowered into the hole until the rotary shoe is a few feet above the top of the fish. Close the rams, start pumps and reverse circulate the hole until the top of the fish is clean.

Reverse circulation is used throughout the washover operation for two reasons: (1) to wash the gravel up into the wash pipe rather than on the outside where it could settle back and stick the wash pipe; (2) to clean the hole faster by increased velocity of the returns which should speed up over-all operation.

Normal pump pressure is used throughout the operation, in this case about 200 to 400 psi, since excessive pressure while reversing might break down the formation and seriously impede normal well productivity. After circulating until returns indicate the top of the fish is clean, lower the string slowly, until the mouth of the rotary shoe passes over the fish.

If a conventional rig is used for working over the well, the kelly is generally used for the washover operation; however, at times a drive bushing (Figure 5) can be used for this purpose, especially if the length of fish to be washed over is short. If a rod and tubing unit is used for the workover operation, the pipe is raised and lowered with the hoisting equipment and rotated, as the occasion arises, either manually or with air or hydraulic

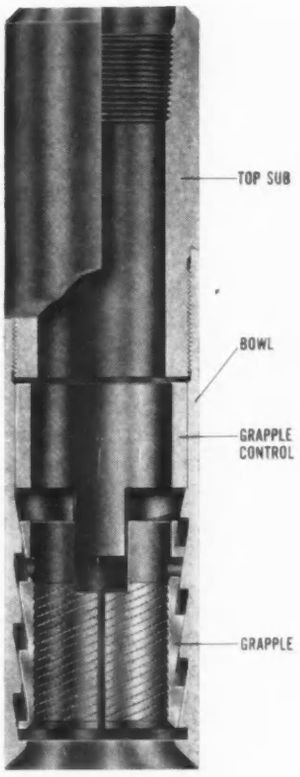


FIGURE 7—Short catch overshot is used where limited amount of space is available to anchor the overshot.

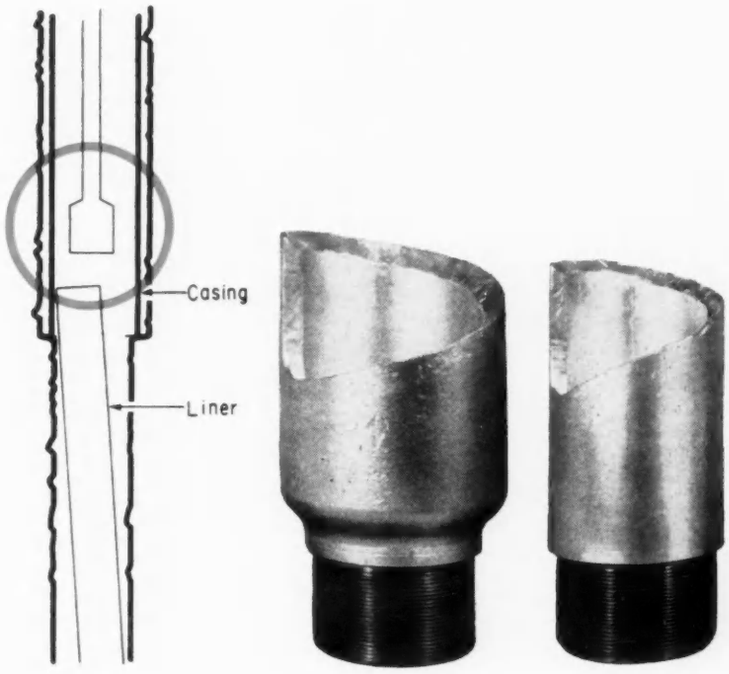


FIGURE 8—Quite often the liner will lean over to the side of the casing, this necessitating rotating the spiral lip guide over the fish.

tongs. The latter is generally preferable because of the extra torque provided.

In lowering the rotary shoe over the fish, it is not necessary to rotate the pipe; in fact, throughout the washover operation it usually is not necessary to rotate the pipe except to cut or mill off the centralizers. As the string is lowered, the high velocity of the fluid across the face of the rotary shoe jets the sand and gravel into the restricted area between the liner and the inside of the wash pipe.

Sometimes, a stubborn streak of sand and gravel may require both rotation and weight to penetrate. In this case, moderately slow rotation, from 10 to 80 rpm, depending on the equipment at hand, and 1,000 to 2,000 pounds weight on the shoe should be sufficient to break through.

When the first centralizer is reached, rotation of the pipe is begun and light weight is applied. If a carbide rotary shoe is used, rotary speeds can be somewhat higher than for conventional mill type or flat-face burning shoes; however, in no case should speeds exceed 80 to 100 rpm, since the danger of twisting off the 2-inch tubing above the wash string is increased greatly. This is especially true if a larger workover rig is used, since the high horse power output is not readily controllable. Excessive torque may be induced in the light string before the rotary table can be stopped.

If a conventional shoe is used, speeds of from 30 to 50 rpm will generally be most satisfactory.

It should be noted that many centralizers have been cut off at 5 to 10 rpm, with the pipe being rotated with chain tongs. Indeed, from the standpoint of control, it would be difficult to find a better method, since a trained operator can tell by the "feel" of the pipe just how the cutting operation is progressing at all times. Weights can be controlled more effectively and the danger of a twistoff is eliminated.

Note in Figure 1 that two centralizers are used on each section of the liner and screen and are spaced three feet from the joint or threaded connection. This is the usual spacing practice and, though it works well from the standpoint of centralization, it is not the best practice as far as fishing is concerned.

When running the liner, elevators and tongs are in contact only with the three-foot section above the centralizer, resulting in nicks and scratches on this section. After remaining in the well for an extended period of time, the end portions of the liner, due in part to the surface imperfections, are more susceptible to corrosion than the center section.

As a result, the liner often may pull in two in the weakened end portion, leaving only 1 or 2 feet of liner projecting above the centralizer. This limited space above the centralizer impedes further fishing operations since a standard catch overshot (Figure 6) will not anchor in the short section. Sometimes, where only a few inches of space remain, even a special short catch overshot (Figure 7) will not work.

This means that either an extra trip will be required to remove the centralizer or that a spear will have to be used in place of the overshot. The overshot, of course, is a much more satisfactory grappling tool for this operation because it will support heavier pull loads than the spear.

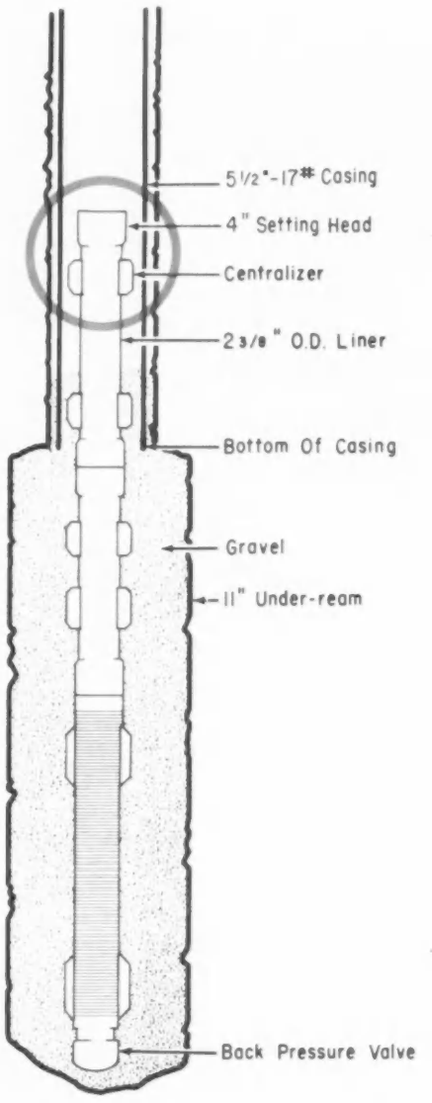


FIGURE 9—A liner is set in open hole with the upper end in casing and a 4-inch OD setting head is screwed into the top of the liner.

For faster, trouble-free fishing, the best spacing for centralizers on liners is five feet or more from the threaded connection. This allows ample room for grappling tools and does not alter the effectiveness of the centralizers.

After contacting and milling partially through the bottom centralizer, the liner usually will begin to turn with the wash pipe making further milling impossible. When it becomes evident that no further penetration will be made, rotation is stopped and the rotary shoe is picked up about 18 inches or 2 feet off the centralizer. Reverse circulation then is continued for about 15 or 20 minutes at the highest pressure compatible with well conditions. Purpose of this is to force all sand and gravel possible up into the wash string for friction purposes.

The pipe then is jarred downward with a snap action and an attempt should be made to drive the rotary shoe completely over the bottom centralizer.

With pipe in this position, stop circulation and wait about 15 minutes, giving the sand and gravel in the wash pipe ample time to settle down and pack tightly around the liner and screen inside the wash pipe. If all goes well, the liner then may be pulled from the hole, held securely in the wash pipe by the tight gravel pack and also by the friction grip between the wash pipe and centralizers which are purposely milled to fit tightly in the pipe.

► **Fourth Operation.** If for any reason the liner is not retrieved with the wash pipe, make up string from bottom to top as follows:

- Four and one-eighth-inch OD overshot with lip guide and stop to catch on $2\frac{19}{32}$-inch upset
- Bumper Jar
- Oil jar
- Two-inch tubing to complete the string.

Lower overshot in the well and contact top of the fish. With the bottom of the overshot about 2 or 3 feet above the fish, start the pumps and clean the top of the fish with direct circulation.

Rotate pipe slowly while lowering the string and allow the spiral lip guide of the overshot to hook the fish which probably lies against the casing wall (Figure 8). As the overshot is lowered over the fish, the grappling members or slips are forced upward on tapered seats, thus allowing these members to expand and permitting easy entry of the fish.

To pull the fish, take all torque out of the string and exert an upward strain on the pipe. Friction of the slips on the fish holds slips stationary as the tapered bowl is raised. This causes slips to contract and grip the fish tightly, so it may be pulled from the hole. If necessary, jars can be used to start the fish moving.

In no case should a spear be used in the above operation as a substitute for the overshot. After milling the centralizers off the liner, the fish is no longer centralized in the well, and is free to lay over against the casing wall. In such a position, it is difficult to insert a spear into the top of the fish, in most cases, the small diameter tool will slip down beside the fish and wedge so tightly that a separate fishing operation may be required to remove it.

Case B. Same as Case A, except that a 4-inch OD setting head is screwed into the top of the 2⅜-inch OD flush joint liner (Figure 9).

Fishing operation

► **First operation.** Same as Case A

► **Second operation.** Same as Case A

► **Third operation.** The large 4-inch OD setting head set inside 5½-inch, 17-pound casing prohibits a washover operation as suggested in Case A since there is insufficient clearance between the setting head and the casing.

Because the setting head is the only obstacle preventing a washover operation, it should be removed so the more economical outside recovery operation, can be performed. For this purpose, a cutter and spear combination is best. Make up string from bottom to top as follows:

- 2-inch inside cutter, 1¾-inch OD, preferably with automatic bottom
- Sufficient 1¾-inch OD Spacer nipples to make a ten-foot cut—in this case, about 15 feet of spacer pipe
- 2-inch shoulder or bumper-type spear, 1⅞-inch OD
- Cage by 3⅛-inch OD shoulder to stop in bottom of setting head.

- Two-foot, 3-1/16-inch OD long spear extension sub. One or two joints of 2-inch tubing or drive pipe for weight
- Two and seven-eighths-inch bumper jar (3-1/16 inch OD)
- Two and seven-eighths-inch hydraulic jar (left in string from previous run)
- Two-inch tubing to complete string.

Fifteen feet of spacer pipe is used between the cutter and the spear so that 10 feet of fish can be cut without inserting the spear into the fish.

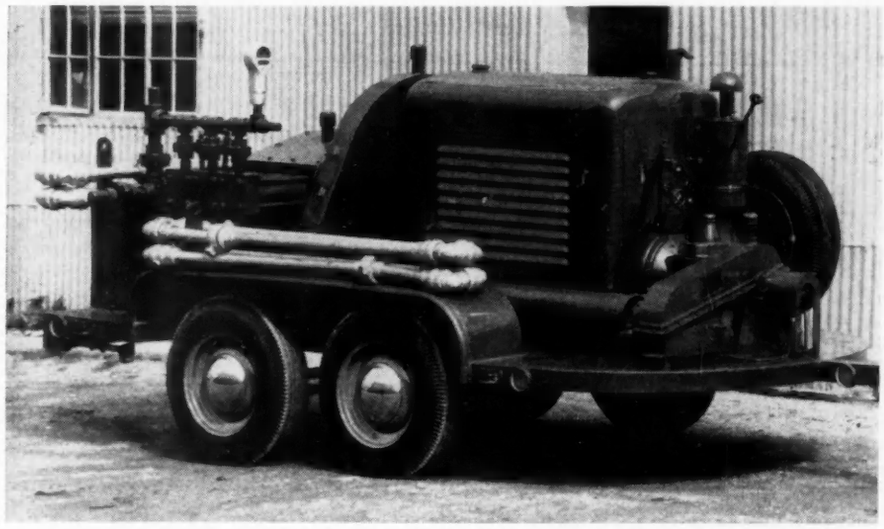


FIGURE 10—A trailer-mounted high-pressure pumping unit.

The hydraulic jar is present in the string only because it was used in the previous run and to remove it would require extra rig time. As a general rule, it would not be needed in this operation.

After lowering the cutter in the hole to a point just above the top of the setting head, circulate the well until the top of the fish is clean. Check dead weight on indicator and note. Lower the cutter into the fish without rotation until the spear stop bumps up in the bottom of the setting head. Rotate fishing string 1 or 2 turns to the right to release spear. Pick up string 5 to 6 feet which will position the knives about 10 feet below the top of the setting head. Rotate pipe slowly to the right while lowering the cutter about 10-12 inches. This operation causes the slips on the cutter to set in the liner and, at the same time, allows the bumper jar to close partially so that only the weight of the pipe below the jar will be on the cutter. This means the cut will be made with predetermined or controlled weight, eliminating or at least greatly reducing the tendency of the knives to chatter and break.

Rotation of 10 to 36 rpm—depending on whether the operation is performed manually or with power—is continued until a lessening of torque indicates the cut has been made.

Cutter then is elevated about 6 to 8 inches, freeing the slips from the liner and causing the rachet type automatic bottom to re-engage, thus placing the cutter in the released position.

String is lowered until spear packoff enters the fish and the shoulder or bumper ring of the spear comes to rest in the bottom of the setting head. During this operation, pumps are shut off so as not to damage the packoff element while entering the fish.

To insure that the spear is in the catch position, turn the string from 1 to 2 turns to the left. While spears are run into the hole in the catch position, they sometimes work around into the release position, especially during a cutting operation when it is necessary to turn the pipe to the right for several minutes.

Pick the string up slowly and, if no resistance is met, pull out of the hole. If the cut portion is stuck so tightly that it cannot be pulled, the hydraulic jar may be used. If necessary, start the pumps and break circulation between the cut portion of the fish and the casing, to loosen the sand and gravel pack.

Usually, a short portion of the fish such as the one described above can be pulled without the aid of any accessory tools or additional operation.

► **Fourth operation.** Proceed with washover operation as described under operation 3, in Case A.

► **Fifth operation.** Same as operation 4 in Case A.

Case C. Same as Case A, except that 5½-inch flush joint liner has been set inside of 7-inch, 26-pound casing.

Fishing operation

► **1st operation.** Same procedure as Case A.

► **2nd operation.** Same procedure as Case A.

► **3rd operation.** Since 5½-inch flush liner has been set inside of 7-inch casing, a washover operation is out of the question. The fish will necessarily have to be retrieved by an "inside" method. Since the large OD liner will support very heavy tensile loads, a hydraulic pulling tool should be used for this recovery operation.

Make up string from bottom to top as follows:

- 5½-inch inside cutter with automatic bottom
- One 30-foot single, 2½-inch EUE tubing
- 5½-inch spear (4¾-inch OD) with bumper ring to stop 5½-inch OD liner
- 3½-inch safety joint, 4¾-inch OD
- 3½-inch drain sub, 4¾-inch OD
- 3½-inch bumper jar, 4¾-inch OD
- 7-inch pull tool, 5½-inch OD
- Sufficient 2½-inch EUE production tubing to complete string

Since a workover rig with limited pump capacity normally would be used, it is necessary to bring in a portable or trailer-mounted high pressure pumping unit (Figure 10). The unit should be capable of building up and sustaining down-hole pressure of 5,000 or 6,000 psi. This will provide sufficient pressure to utilize the full

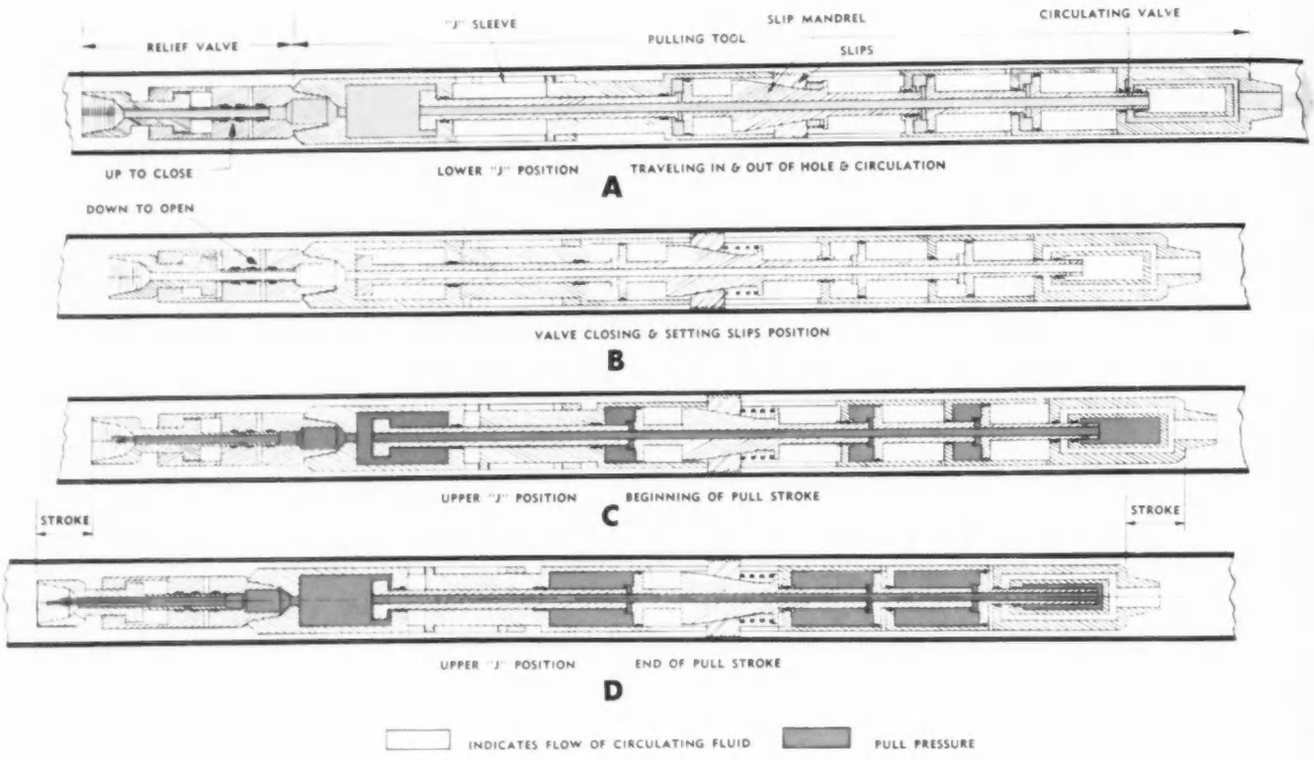


FIGURE 11—Schematic diagram of a hydraulic pulling tool.

efficiency of the pull tool. If only moderate pressures can be attained, efficiency is low and there is little advantage in running the hydraulic tool.

Proceed into the hole and position the bottom of the internal cutter a few feet above the top of the fish. Circulate until returns indicate the fish is clean.

Without rotating, lower the string and cutter into the liner until the shoulder ring in the spear bumps against the upper face of the liner.

Raising the string slowly will cause spear slips to expand on their tapered seats and engage the fish. In some cases, depending on the type spear used, it will be necessary to rotate the spear mandrel to the left as much as one full turn before raising the pipe. This will insure that the spear is in the catch position.

After sufficient pull has determined that the fish is securely caught, the hydraulic pull tool should be brought into operation.

Some pull tools require that a ball be dropped into the string to seal off circulation and divert fluid pressure into the pull side of the pistons and cylinders. Others do not require the dropping of a ball into the string, but are sealed off by the manipulation of a valve within the tool.

In any event, after pumping the ball down to its seat or closing the circulation valve, manipulate the tool to set the slips and place the pistons and cylinders in pull position.

Figure 11 shows the operative position of a typical pull tool. Figure 11A shows the tool in position for lowering into or coming out of the hole, the circulation passage through the tool is open so that the string can fill up going in the hole or drain when coming out. Figure 11B shows the tool after the fish has been engaged. The tubing or pipe carrying the tool has been rotated to the left to disengage from the lower J position shown in Figure 11A, and lowered, pushing the mandrel down to set the slips and close the circulating valve at the bottom of the tool.

At the same time, a relief or bypass valve is temporarily opened at the top of the tool.

After setting the slips, left hand torque is applied and the tool is picked up placing it in the upper J or pulling position (Figure 11C). This closes the bypass or relief valve at the top of the tool so pump pressure can be built up in the fishing string and tool.

A considerable strain then is taken on the fish. Most of the pull tools available today are so designed that mechanical pull from the rig floor can be used to augment the compounded hydraulic forces of the cylinders.

The initial strain taken from the rig floor usually is much less than the maximum allowable pull permitted on the pipe and rig equipment. Obviously, one of the reasons for using the pull tool is to save wear and tear and unnecessary jarring action on the equipment. These tools are designed to harness, compound and apply hydraulic energy with such efficiency that very little additional help is needed.

Since a workover rig with a maximum allowable pull of 180,000 pounds is being used, an initial strain of 25,000 or 35,000 pounds above the weight of the pipe and tools is applied to the fish.

Because the 2½-inch EUE production tubing is used as the fishing string, this strain plus the weight of the 7,000-foot string, buoyancy considered, is within the limits of the equipment.

Apply pressure to the tool, using the high-pressure portable pumping unit (Figure 10) in "second" or No. 2 drive position, providing a volume of 8.56 gpm at 3,300 psi.

When pressure is applied, it is confined within the

tool on the top side of the pistons and cylinders.

Since the pistons are prevented from moving downward by the slips which are anchored in the casing, the cylinders tend to rise, pulling the fish below.

At 3,300 psi, neglecting friction, and other losses this tool will exert a pull of 198,000 pounds. This pull, plus the 10,000 to 35,000 pounds pull from the rig floor, yields a combined loading of 208,000 pounds on the fish.

If the fish fails to move, increase pressure to 5,000 psi. This exerts a pull of 310,000 pounds on the fish.

If this attempt is unsuccessful, apply 6,000 psi pump pressure to the tool. This results in a combined load of 370,000 pounds on the fish.

This is the maximum recommended load on the jars beneath the pull tool and, as a general rule, should not be exceeded. However, in a last ditch effort to save another trip, these limits often are ignored and additional strains from the rig floor are applied to augment the pull on the fish.

If all attempts to pull the fish by the hydraulic method fail, the cutting and pulling recovery method will have to be applied.

First, it is necessary to release the spear from the liner. This is done by dropping the weight of the fishing string on the spear. This operation requires some experience since raising and dropping the entire weight of the string on the spear would cause the drill pipe to bend and corkscrew, resulting in permanent damage. In this operation, pipe is handled as it were a rubber band with a weight on the end. The pipe actually is dropped only a foot or so at the rig floor, but the inertia in the string resulting from the acceleration due to gravity causes the pipe to stretch after the brakes are applied at the rig floor.

This produces a snap action in the lower part of the string, causing the impact faces of the bumper jar to strike downward with great force, breaking the freeze on the spear slips.

In this case, where close to 375,000 pounds pull has been applied to the spear mandrel and slips, repeated jarring may be necessary to release the tool.

After the spear is freed from the liner, turn the pipe 1 or 2 turns to the right and raise the string so the spear is from 5 to 10 feet above the top of the liner. In this position, the spear is not only out of the liner but also the knives of the cutting tool below are spaced so they will not be cutting a joint.

Rotate slowly to the right and lower, or "inch the pipe," downward into the hole. This movement unscrews the slip cage of the cutter from the nose piece, causing the slips to expand on the mandrel and set tightly in the liner. This prevents any subsequent creepage of the tool during the cutting operation. Once the slips are set, the pipe is lowered an additional 10 or 12 inches, partially closing the bumper jar on top of the cutter and spear assembly. Thereafter, all pipe and tools above the bumper jar are in suspension from the rig floor, while all tools beneath the jar—including drain sub, safety joint, spear and 2½-inch EUE single, weighing about 300 pounds—are resting on the cutter and feeding the knives into the pipe with proper cutting pressure.

Turning at 18 to 36 rpm a cut generally is made in from five to 20 minutes. After completing the cut, pick the pipe up about 12 to 14 inches. This frees the cutter slips from the liner and causes the automatic bottom to re-engage, placing the tool in the released position. The string then is lowered without rotating until the bumper ring of the spear contacts top of the cut liner.

With about 1,000 to 2,000 pounds weight on the spear, turn the string 1 or 2 turns to the left. This insures that the spear is in the catch position.

Pick up the string and try to come out of the hole with the cut portion.

If the cut portion still is stuck too tightly, bring the pull tool back into operation. Sometimes, it is necessary to release the spear and make another cut above the point where the first cut was made. If the first cut was made 20 feet below the liner top, the second cut would generally be made at 10 feet, then 5 feet, etc., until the cut piece can be pulled.

Case D. Same as Case A, except that a canvas packer without hold-down slips has been used to seal the annulus between the top of the liner and the casing. Also, the liner is equipped with a slotted screen wrapped with stainless steel wire.

1. Hookup, bottom to top. Back-pressure valve, one joint of 5-inch OD slotted screen wire-wrapped to 5¼-inch OD, three joints of 5-inch OD, 15-pound liner with $5^{9}/_{16}$-inch OD couplings, two centralizers for each joint of liner, 7-inch canvas-type packer. Fluid level of well 500 feet above packer.

2. Hole conditions. Straight hole with no gravel pack. Fine sand has stuck liner all the way to the packer and has penetrated the wire-wrapped screen and filled up inside of liner. Screen and one-half joint of liner are in open hole. Well history shows that in the early stages of production high pressures have been occasionally encountered.

3. Fishing operations.

► **First operation.** Same as operation 1 under Case A, except that 2⅜-inch external flush joint pipe is used instead of $1^{13}/_{16}$-inch. Therefore, when rotation is necessary to break through stubborn streaks, more torque can be applied to the string. DO NOT drill out the back-pressure valve.

► **Second operation.** Since high pressures have been encountered in the area, it would not be wise to try to pull the entire packer and liner assembly at one time. During the pulling operations, the canvas packer might roll and ball up in the casing to form a piston. If the screen were plugged, a swabbing action would take place, resulting in a serious problem if gas were pulled into the well. Thus, for safety and to prevent possible well damage, it will be necessary to remove the packer and liner by cutting rather than pulling.

Make up string from bottom to top as follows:

- 5-inch inside cutter with automatic release.
- 20 feet (minimum length) of 2⅜-inch external flush spacer pipe, generally consisting of four 5-foot nipples. If these are not available, a 30-foot joint of production tubing may be used.
- 5-inch spear with 5⅛ inch OD spear stop. This OD is small enough to permit adequate circulation

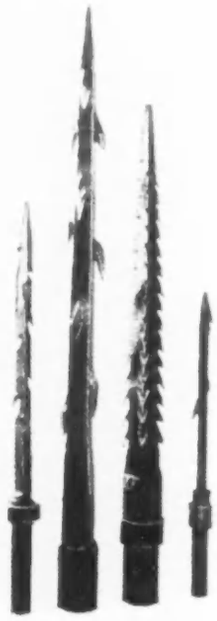


FIGURE 12—Center wire rope spears used to retrieve canvas packers without hold down slips.

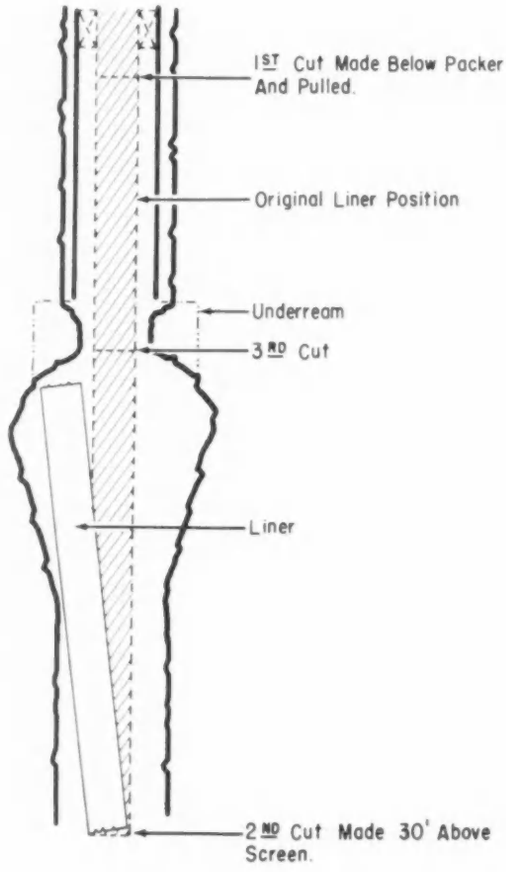


FIGURE 13—The liner is resting on one side of the hole after it was cut just below the casing.

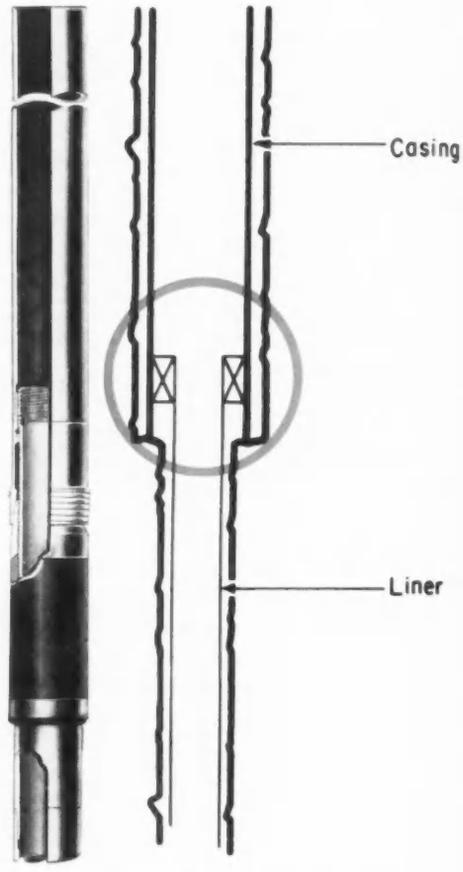


FIGURE 14—A liner that has been set in an open hole using a liner-packer with externally set hold-down slips and a rubber packing element.

and yet is large enough to prevent entry into any part of the liner string, even if a collar were looking up.

- 3½-inch safety joint, 4¾-inch OD. One 4¾-inch OD × 20-foot drill collar for weight.
- 3½-inch drain sub, 4¾-inch OD.
- 3½-inch bumper jar, 20-inch stroke, 4¾-inch OD.
- 3½-inch oil jar, 4¾-inch OD.
- Four 4-inch or 4¼-inch OD drill collars for mass.
- Enough 2½-inch production tubing to complete string.

Proceed as in operation 3, Case A. Insert the cutter into the liner until the spear stop rests against the top of the canvas packer assembly.

Release spear and elevate string until cutter knives are 10 feet below the top of the packer. Make a cut at this point.

If it cannot be pulled or jarred successfully, elevate the string until cutting knives are in the bottom portion of the inner sleeve of the packer. This point is a few inches below the bottom of the canvas. Make a cut at this point and pull and jar the inner sleeve out of the packer.

After recovering this portion of the packer, remove the cutter and 20 feet of spacer nipples from the string; dress the spear with wipers and slips to catch in the outer sleeve of the packer. Go back in the hole and pull and jar the outer sleeve out of the hole.

Go back with the cutter-spear-jar combination and attempt to get inside the liner. If the canvas has balled up and prevents entry into the fish, go back with a center wire rope spear (Figure 12), hook the canvas and pull it out of the hole. In some obstinate cases it may be necessary to go back with a conventionally dressed flat-bottom shoe, burn over the canvas and pump the bits out of the hole.

After removing the canvas, go back with the cutter-spear-jar combination and proceed to jar the upper cut portion of the liner, measuring about 5 feet after the removal of the packer, out of the hole. Thereafter, cut and jar the liner and screen out of the hole piecemeal until the well is cleaned out.

One precaution: NEVER cut in the area directly adjacent to the bottom of the casing. Always make a cut at least 10 feet above or at least 15 feet below the casing.

If the liner is cut just below the casing, it may fall to one side and make re-entry impossible without the use of additional tools and several extra trips (Figure 13).

After reaching the stuck screen, some difficulty may be encountered as a result of the stainless steel wire wrapping. Actually, the inside cutting operation will proceed smoothly. However, when the cut portion is pulled, the wire generally will hang up in the tight sand and pull off the screen. After surfacing, if the wire has pulled off, it then is necessary to go back with a center wire rope

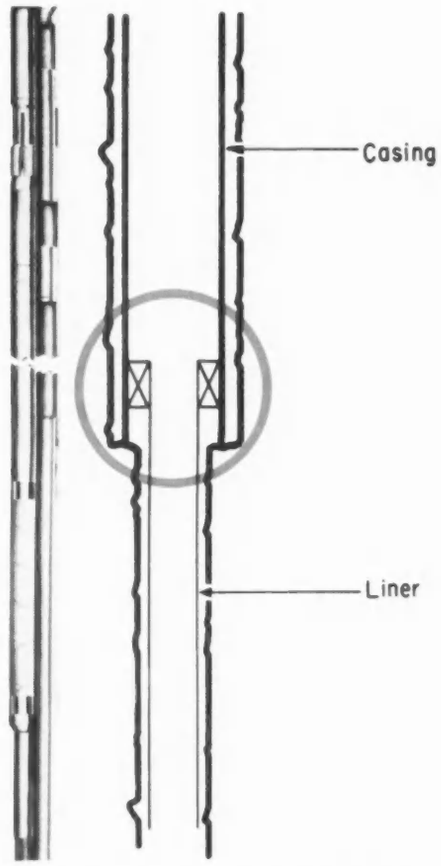


FIGURE 15—Liner set in an open hole using a liner packer with internally set hold-down slips and a canvas packing element.

spear and remove the loose wire before continuing the cutting operation.

In this specific case, no attempt was made initially to pull the entire liner and packer assembly because of the danger of swabbing in a high pressure area. If there had been no danger of high pressure, an alternate method of recovery would have been to first drill out the back-pressure valve and then try to pull and jar the complete assembly loose. This method has been used successfully many times; however, on occasions, serious consequences have resulted from swabbing in a "dead" well. In this case, the safe method is in the slow method—cut and pull.

Case E. Same as Case D, except that a liner-packer with externally set hold-down slips and a rubber packing element has been used (Figure 14).

Fishing operations

► **First operation.** Same as operation 1, Case D.

► **Second operation.** Since this well also is assumed to be in a high-pressure area, no attempt should be made to pull the entire packer and liner assembly at one time because swabbing might result. Accordingly, the packer should first be removed by the inside cutting method.

Make up string and proceed generally as in Operation 2, Case D. Make a cut in the lower extension of the inner sleeve of the packer about 10 feet below the top of the packer or releasing sleeve. Release cutter and lower string until the bumper stop of the spear comes to rest against the upper face of the outer or releasing sleeve of the packer. Set the spear and attempt to pull and jar the packer hold-down slips loose from the casing. Normally, after the inner sleeve has been cut below the packer, the upper or releasing sleeve can be pulled or jarred upward to effect an easy release.

If the fish cannot be pulled or jarred successfully, release the spear and elevate the string until the cutter knives are just above the slip cone. Make a cut through the inner sleeve only at this point. DO NOT CUT INTO THE SLIPS. (The cutting of the slips is prevented by adjusting the screw stops outwardly on the upper face of the knife wedge block to prevent the spreading of the knives beyond a given point. This is done on the rig floor before going into the hole.)

Cutting through the inner sleeve at this point frees the inner sleeve from the outer or releasing sleeve and sets up vibration in the slip area, helping to agitate and remove sand from this area and make the slips release more easily.

After making the cut, set the spear in the outer sleeve and pull this portion of the packer together with the slips out of the hole, leaving the slip cone, packer element and inner sleeve in the hole.

In jarring the slips off the cone, a slip sometimes will break off and remain in the hole. In this case, it is necessary to go back with a carbide burning shoe and mill down about 10 or 12 inches below the cone to remove this obstruction.

Go back with a cutter-spear-jar combination and proceed generally as outlined in operation 5, Case D.

Case F. Same as Case E, except that a liner packer with internally set hold-down slips and a canvas packing element has been used (Figure 15).

Fishing operations

► **First operation.** Same as operation 1, Case D.

► **Second operation.** Make up cutter-spear-jar combination as in Operation 2, Case D. However, the spear should be dressed so the distance between the bumper ring and slips is sufficient to allow slips to anchor in the inner barrel of the packer when the bumper ring is resting against the top face of the packer releasing sleeve, or outer barrel.

In this case, the distance between the bumper ring and slips is sufficient to allow the slips to anchor in the inner barrel of the packer when the bumper ring is resting against the top face of the packer releasing sleeve, or outer barrel. Also, the distance between the bumper ring and the slips should be about four or five feet. Proceed into the hole, and, following the general procedure in Operation 3, Case A, make a cut from 10 to 12 feet below the top of the packer.

Release the cutter and set the spear slips in the inner barrel of the packer and attempt to pull and jar the cut portion loose.

► **Third operation.** If successful, release the spear and come out of the hole. Dress the spear for extra short catch, so that when the bumper ring comes to rest on the top of the packer, the slips will catch in the restricted bore at the tip of the outer sleeve.

Go back in the hole with the same hookup as above

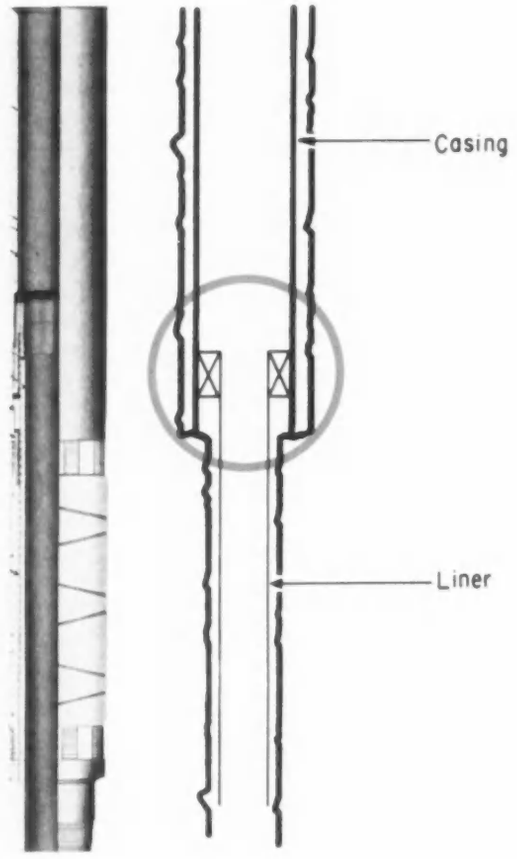


FIGURE 16—A liner set in an open hole with a packer with unrestricted bore.

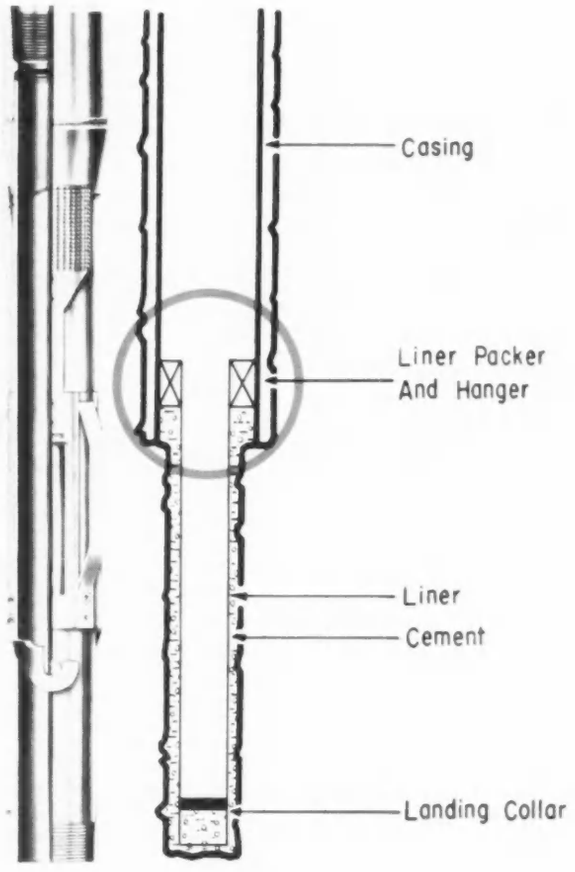


FIGURE 17—Cemented 7-inch liner. Liner hanger shown at left. Refer to Figure 14 for details of liner packer.

and make a cut 12 inches below the top face of the sleeve.

Release cutter, set spear and remove cut portion within the restricted bore from the well. This upper portion of the packer with its restricted bore is cut and removed so the spear may be anchored more securely for jarring operations in the full bore of the outer sleeve.

► **Fourth operation.** After removing this piece, remove the cutting tool from the string, dress the spear to anchor in the full bore of the outer or setting sleeve and go back and jar the outer sleeve out of the hole.

► **Fifth operation.** Dress the spear to catch in the inner barrel of the packer, put the cutter with a 30-foot single back in the string, remove the drain sub and go back in the hole.

When the bottom of the cutting tool approaches the top of the fish, increase pumping rate to capacity and jet the canvas packing element into bits and circulate these pieces out of the hole. This operation usually will require about an hour to complete; but is a safety precaution which must be observed. If the cutting tool is lowered directly into the packer without circulating, any balled canvas on top of the packer will be rammed into the top of the inner barrel and an extra trip will be required to mill up the canvas.

After circulating the canvas from the hole, lower the cutting and grappling tools into the fish, set the spear and jar the portion of the inner barrel which was previously cut out of the hole.

► **Sixth operation.** Replace the drain sub in the string, go back in the hole and proceed (Operation 5, Case D) to cut and jar the liner and screen out of the hole.

Case G. Same as Case F, except that a packer with unrestricted bore has been used (Figure 16).

Fishing operations

► **First operation.** Same as Operation 1, Case D.

► **Second operation.** Same as Operation 2, Case D.

► **Third operation.** Remove the cutter from the string, dress and spear to catch in the outer barrel or releasing sleeve of the packer. Since the bore of the outer barrel is full-opening and not restricted, there is no need to cut off the top of the releasing sleeve as was done in Operation 3, Case F.

Go back and pull and jar the outer sleeve out of the hole.

► **Fourth operation.** Restore the cutter and one 30-foot single to the string, dress the spear to catch in the inner barrel of the packer. Proceed as in Operation 5, Case D, to cut and jar liner and screen out of the hole a piece at a time until the well is cleaned out.

Case H. Short string of liner set off bottom by means of liner hanger and is stuck inside and out.

1. Hookup, bottom to top:

- Back pressure valve
- One joint 5-inch slotted screen

- Four joints of 5-inch, 17-pound liner
- Five-inch liner hanger inside 7-inch, 29-pound casing
- Two centralizers are used on each joint of liner
- No packer is used

2. Fishing operations

► **First operation.** Same as Operation 1, Case A, except that 2⅜-inch external flush joint pipe is used instead of 1 13/16-inch. Thus, when rotation is necessary to break through stubborn streaks, more torque can be applied to the string.

After washing to the bottom of the screen, drill out the back-pressure valve for the following reasons:

1. To reduce the forces necessary to jar or pull the liner. (5-inch OD liner is too long to wash over inside of 7-inch, 29-pound casing.)
2. To provide a hole through which junk accumulating inside the liner may be dumped.

► **Second operation.** Since it is not known how tightly the liner is stuck, proceed as in Operation 2, Case A, to pump, pull and jar the entire liner assembly out of the hole.

Make up string as follows:

- 5-inch inside cutter with automatic-bottom
- One joint 2½-inch tubing
- 5-inch spear packoff
- 5-inch spear with 5½-inch OD stop
- 3½-inch safety joint
- One 4¾-inch OD drill collar
- 3½-inch bumper jar
- 3½-inch oil jar
- Four 4½-inch OD drill collars
- 2½-inch tubing to complete string.

Liner hangers are used when it is necessary to suspend a liner off bottom. Generally, they are set by picking up the string and rotating to disengage the J-hook assembly which controls the positioning of the slips on the slip cone. Some are made to set without rotation since it may be inadvisable to rotate the pipe due to crooked holes, extra long liners, or great depths. Liner hangers are released by picking up the hanger, thereby pulling the slip cone out from under the slips. In view of the simple releasing mechanism, hangers rarely give any trouble in fishing for liners.

► **Third operation.** If jarring is unsuccessful, elevate the string and make an inside cut of about 15 feet below the top of the hanger and jar this portion out of the hole. The purpose of this cut is to remove the liner hanger from the hole so the pull tool can be used directly in the liner.

The hanger, due to its construction, generally will pull in two under the powerful loading imposed by a 7-inch pull tool. At least one extra trip will be required to remove hanger remnants from the hole.

► **Fourth operation.** After removing the hanger from the hole, proceed as in Operation 3, Case C, with a cutter-spear-pull tool combination to clean out the well.

Case I. A liner has been set beneath intermediate string: cemented on the outside from top to bottom and on the inside from float shoe to landing collar (Figure 17). The liner, which has remained in the hole for 15 years, has sanded up and probably has corroded. Until the sanding condition occurred, the well was a good producer.

1. Hookup bottom to top:

- Orifice float shoe
- One joint 7-inch, 20-pound, J-55 liner
- Landing collar and liner wiper plug
- 210 feet of 7-inch, 20-pound, J-55 liner with perforations at producing zone
- Liner hanger
- 9⅝-inch liner packer with hold-down slips
- Top of fish—8,000 feet
- Angle of hole from vertical—37°

2. Fishing operations. Since the liner is cemented over its entire length, conventional methods of recovery, including cutting, jarring, pulling, or backing off, cannot be used. Three possible solutions exist. The choice of any one depends on the potential productivity of the well as compared to the cost of the method. The three solutions are:

1. Mill up the liner completely
2. Mill out a section of the liner or casing for sidetracking
3. Set a casing whipstock.

Of the three methods, setting a casing whipstock is the least costly and the fastest, though not always the most trouble-free method. Milling a section is slightly more expensive but promises a more trouble-free whipstocking operation. However, in this case, the productivity of the well in its present location on bottom is known to be good, and too much risk would be involved in sidetracking or orienting since the new location might not be as productive as the old. In addition, the sand might be missed altogether.

The best solution is to mill up the liner completely. The job should proceed swiftly because a lightweight J-55 liner is involved which may be corroded since it has been in the hole for 15 years. Its condition should lead to increased penetration rates.

However, it should not be concluded that liner milling is always a "last resort" method of recovery. That is not true. On the contrary, rapid progress made in recent years in cutting steel downhole with fragmented tungsten-carbide has resulted in a sizeable reduction in cost. In some cases, the technique compares favorably with other recovery methods.

Penetration rates up to 15 feet per hour have been recorded in open hole. In cases where liners, too large to washover, are stuck tightly, this rate of recovery may be satisfactory when compared to inside cutting and pulling 10-foot sections at a time.

However, these factors must be considered before choosing this method of recovery:

1. Volume of chips of cuttings which must be removed from hole
2. Facilities necessary to remove cuttings
   a. Is pump volume sufficient?
   b. Is mud weight satisfactory?
3. Effect of cuttings on pumping equipment
4. Effect of cuttings left in the hole on future operations

FIGURE 18—A concave junk mill is used to mill up the remaining liner after a portion of it has been removed.

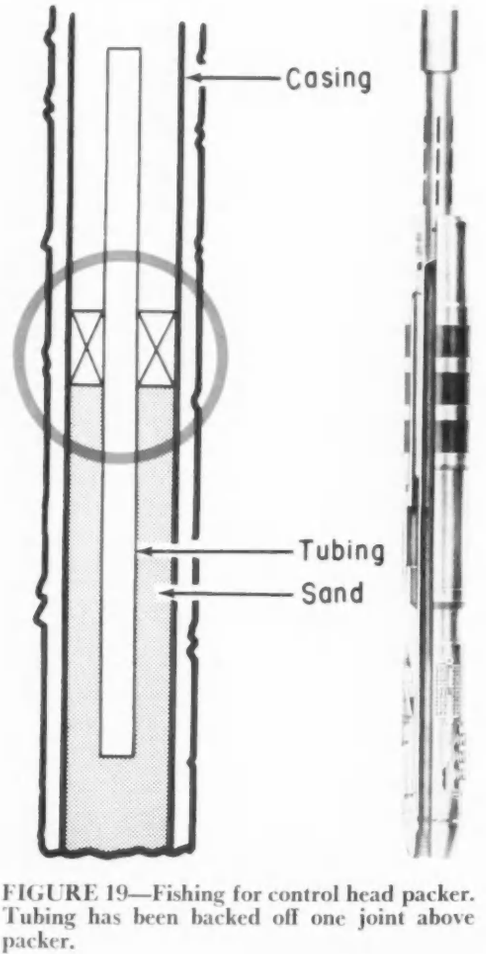


FIGURE 19—Fishing for control head packer. Tubing has been backed off one joint above packer.

5. Cost of replacing liner

6. Are rotary speeds sufficient?

7. Will the job be done with drill pipe or tubing?

8. Will sidetracking be a problem?

If 240 feet of 7-inch, 20-pound liner is to be removed from the hole by the milling method, about two and one-half tons of cuttings must be removed from the hole in from 18 to 36 hours.

Formation cuttings in great volume are one problem, but steel cuttings are another. Considerable volume and pressure are required. Facilities for producing these pressures are frequently not available on workover locations.

Very light muds are not a satisfactory medium for lifting the cuttings to the surface; in fact, when salt water is used, cuttings may remain on bottom. If the mud program must be altered, the additional cost must be considered.

Surface facilities for removing cuttings from the mud stream also must be considered.

A good shaker or screening process with tramp magnets on the down-side is desirable; however, even under the best operating conditions, some of the finer cuttings will get through to the pumping equipment. The effect of these foreign particles on the valves, liners, pistons, etc., must be considered in a comparative evaluation of the method on a specific location. Cost of repairs must be added to the cost of the job.

In addition, all cuttings will not be returned to the surface under the best conditions. If 20 percent of the chips remain in the hole as settlings (960 pounds, in this case), future remedial operations may be more or less impeded.

If the entire liner is milled up, the cost of replacing the pipe must be weighed against how much of it could be saved by using a different recovery method. If a washover is possible, the entire liner and screen may be recovered intact. Even when cutting or pulling, often it is possible to recover several joints at a time.

To get maximum results when milling with fragmented carbide, relatively fast rotary speeds should be available, as well as drill collars and drill pipe. The use of tubing retards the penetration rate.

The possibility of sidetracking should be considered, especially if the hole is very crooked or the pipe to be milled is not uniform. Split pipe, pipe with washed out or corroded sections, egged or collapsed pipe, etc., have a tendency to cause a non-uniform thrust loading on the bottom of the mill. This concentrates the load on one side of the mill and causes the mill to deviate and walk out of the pipe. With proper design, most of these problems can be minimized.

If these problems can be solved, milling with fragmented carbide should be considered.

In the case under consideration, most of the above conditions are met. However, even if they were not, there would be no other choice since the liner is cemented from top to bottom and the economics of production dictate restoration of the original hole rather than sidetracking or re-orienting.

► **First operation.** Before milling operations can begin, the inside of the liner should be washed out, since the packed sand would retard the milling rate. In milling short sections of liner, it is often possible with a properly

designed mill to do both operations at once, using the pilot of the tool to stir up and jet out the sand ahead of the milling teeth. But in milling long liners, this dual operation is often unsatisfactory since an abrasive sand will quickly cut the teeth off the pilot drill. This leaves a smooth rounded surface to spin in the sand, thus stopping the pipe milling operation.

Make up a string from bottom to top as follows

- 6¼-inch OD diamond point bit with enough 3½-inch drill pipe to complete string
- Go in hole, wash out liner to the landing collar, drill out the back-pressure valve and 30 feet of cement down to the float shoe.

► **Second operation.** Before beginning the pipe milling operation, the packer and hanger at the upper end of the assembly must be removed. Since the liner is cemented up to and around the packer, no attempt should be made to cut and pull this portion of the fish. Instead, it should be milled up. For this purpose, a concave junk mill should be used (Figure 18). This heavy-duty tool is designed to stand up under the most gruelling downhole conditions.

Make up string as follows:

- 8¼-inch OD concave junk mill with stabilizing wings for centralization in 9⅝-inch, 40-pound casing
- Two 8¼-inch OD stabilizers spaced at intervals of 60 and 120 feet above the bit
- Six 6-inch OD drill collars for weight
- Enough 4½-inch drill pipe to complete string.

Run in hole and contact top of the fish at 8,000 feet. Begin circulating and adjust pump pressure to maintain about 1,500 psi. Rotate the pipe at 95-100 rpm, set about 10,000 pounds weight on the bit and mill up the packer and liner hanger assembly. For ideal penetration rate, it will generally be necessary to try different rotary speeds, weights and pump pressures. Rotary speeds may vary from 60-175 rpm, weights 5,000-20,000 pounds and pressures (at this depth) from 1,200 to 1,800 psi. When penetration rates decline, any of these factors may be varied to again speed up the operation. Occasional spudding also may help.

The volume and characteristics of cuttings recovered from the shale shaker should occasionally be checked, since a great deal of information about the milling operation can be obtained from this source.

► **Third operation.** Make up string as follows:

- 7⅝-inch OD pilot mill with extra long pilot
- 6¼-inch OD smooth-ribbed pilot to prevent sidetracking
- Six 6-inch OD drill collars
- Two 8¼-inch OD stabilizers spaced at 60 and 120 foot intervals above the mill
- Enough 4½-inch OD drill pipe to complete string.

Proceed into hole, begin pumping at 1,500 psi and begin milling with light weight (about 5,000 pounds) and moderate speed until the top of the fish is dressed off.

If the top of the pipe has been severely damaged or closed in by the junk milling operation, an extra trip with a taper mill will be required to re-open the top of the fish.

If the milling operation progresses smoothly, weights and rpm may be increased slightly. In this case, *very* heavy weights should not be used. Because of the high angle, crooked hole and the fact that corrosion has probably attacked and weakened the liner, the tendency to side track has been greatly increased. Rotary speeds of 60 to 75 rpm and weights of from 5,000 to 7,000 pounds will probably give more satisfactory results, though the penetration rates will be somewhat slower.

Barring complications, the job should be completed with three mills in about two or three days. During this time, returns should be checked to determine whether cuttings are being circulated out of the well. As the bit works farther down the hole out of the casing, it may be necessary to reposition the stabilizers or even add more to the string; however, in this case the cement itself will tend to serve as a cylinder and stabilize the bit.

RECOVERY OF PRODUCTION PACKERS

Several production or hookwall packers are available today. To describe each in detail and the necessary recovery operations is beyond the scope of this manual. Basically, these packers may be divided into two types: those which require weight from the tubing string to set and hold the packer and those which do not require tubing weight, but are set either hydraulically or mechanically by rotation.

Hookwall packers. The so-called "control-head" or weight type packers are generally provided with one set of slips and one packoff whereas the hydraulic and rotary types are usually provided with dual packoffs and dual slips for hold-down.

Various other features, including large volume by-pass, safety joint, torque jars, rocker type slips, etc., are incorporated into some packers. Most production packers of this type are not drillable since they are designed to be retrieved with the tubing string.

The following cases were selected to illustrate the recovery of any type of production packer on the market today.

Case A. Control head circulating packer set at 5,500 feet in 5½-inch, 20-pound casing. One joint of 2-inch non-perforated production tubing below packer. Tubing string has been washed over and backed off down to packer, leaving one joint of 2-inch production tubing with 3$^{1}/_{16}$ OD collar above the packer (Figure 19).

Make up string as follows:

- 4-inch OD spiral grapple overshot with packer and 3$^{1}/_{16}$-inch collar stop
- 3⅜-inch OD bumper jars
- 3⅜-inch OD hydraulic jars
- Three 3½-inch OD drill collars
- 2-inch production tubing to make up string.

Lower the string into the well until the overshot is a few feet above the top of the fish and circulate until returns indicate the area around the fish is clean.

Discontinue circulating, turn the string slowly to the right and lower the overshot over the fish. When the wickers on the spiral grapple contact the fish, sufficient friction is established to force the grapple upward into

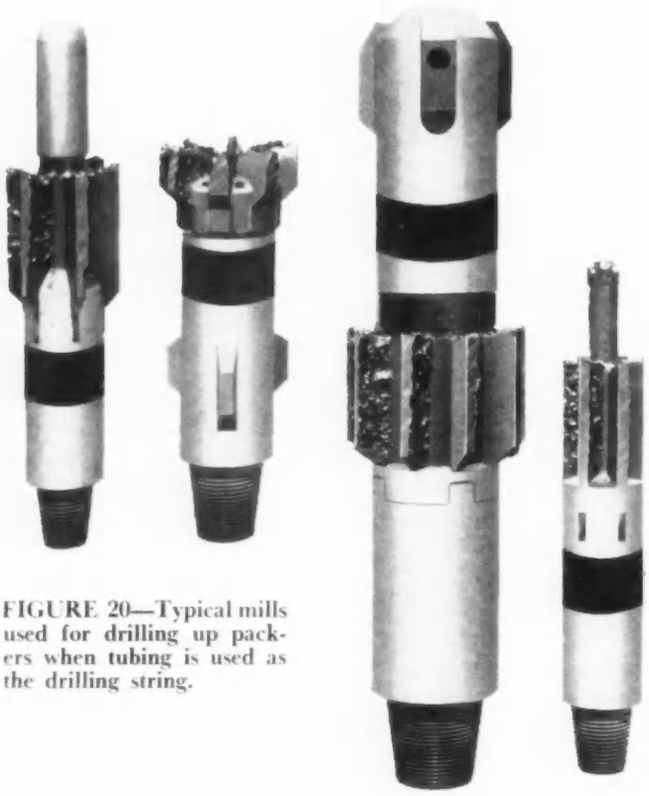


FIGURE 20—Typical mills used for drilling up packers when tubing is used as the drilling string.

the bowl (Figure 6), thus permitting easy entry of the fish.

When the collar stop in the overshot bumps up on the top of the fish, take all torque out of the string and take an upward pull on the pipe. This causes the grapple within the overshot to move downward relative to the bowl, contracting the spiral slip and forcing the wickers into the collar of the tubing of fish.

Take a strain of about 10,000 pounds above tubing weight on the fish to be sure that the overshot is tightly engaged.

Apply maximum pump pressure compatible with well conditions and attempt to pump and pull the packer uphole.

If this is unsuccessful, reduce pump pressure and, with the hydraulic jars set to trip at about 20,000 pounds under the maximum allowable strain in the pipe (in this case, 50,000 pounds), attempt to pump and jar the packer out of the hole. In many cases, pressuring the formation will not be permitted and only the jarring action may be used.

In any event, if the packer cannot be moved, continue jarring until the packer mandrel fatigues and snaps in two at or near the threaded connection between the upper seal and the stem. This will allow the inner stem to fall down below the packer.

Go back with a spear and jar combination. Set the spear in the outer barrel or sleeve of the packer, and try to jar it loose.

If unsuccessful, go back with a tungsten carbide mill and mill up the packer and recover the bottom production tube with an overshot.

The only alternative to the milling operation would be to remove the packer from the hole a piece at a time by the jarring method. This would require a number of runs and several days' time, whereas the packer can be drilled up by the tungsten carbide method in about six or seven hours.

Figure 20 illustrates the type of mill used to drill packers when tubing is used as the drilling string. While this type of production packer is not classed as drillable, it is made of relatively soft material when compared with most down-hole equipment and should drill up easily. A tungsten carbide junk mill also can be used to drill up this type of packer; however, in most cases the penetration rates will be somewhat slower.

Weights of 5,000-12,000 pounds and rotary speeds from 60 to 125 rpm are used when running packer mill. Pump pressure of around 1,000 psi should be sufficient at this depth.

Case B. Seven-inch mechanical packer (Figure 21) has become sanded up and corroded at 9,600 feet so the stem cannot be rotated to the right to release the seals and slips. One joint of 2½-inch tubing has been left above the packer. Fifteen-foot perforated nipple below packer is stuck tightly.

Fishing operations

► **First operation.** Since the packer stem cannot be rotated to release, there is a strong possibility that the perforated nipple below the packer is stuck tightly and is causing most of the trouble as far as rotation is concerned.

The best approach is to sever the nipple from the packer by making an inside cut just below the packer

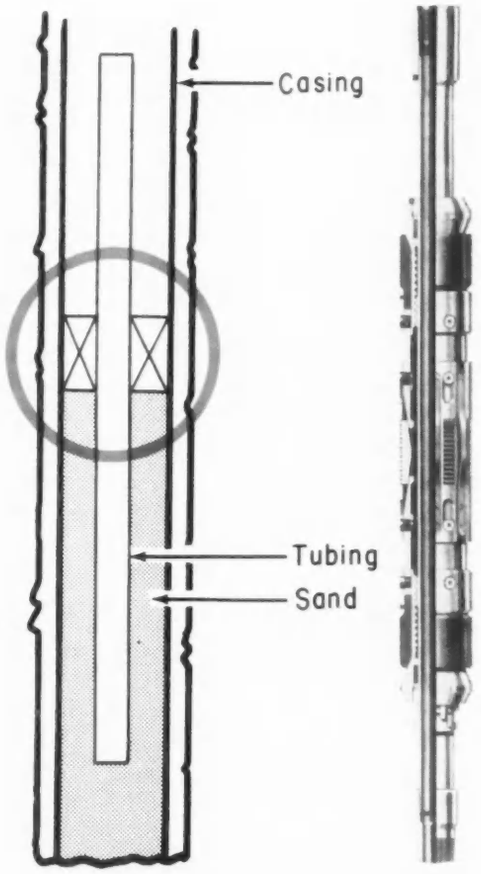


FIGURE 21—A mechanical packer has become sanded up with a joint of 2½-inch tubing left above the packer.

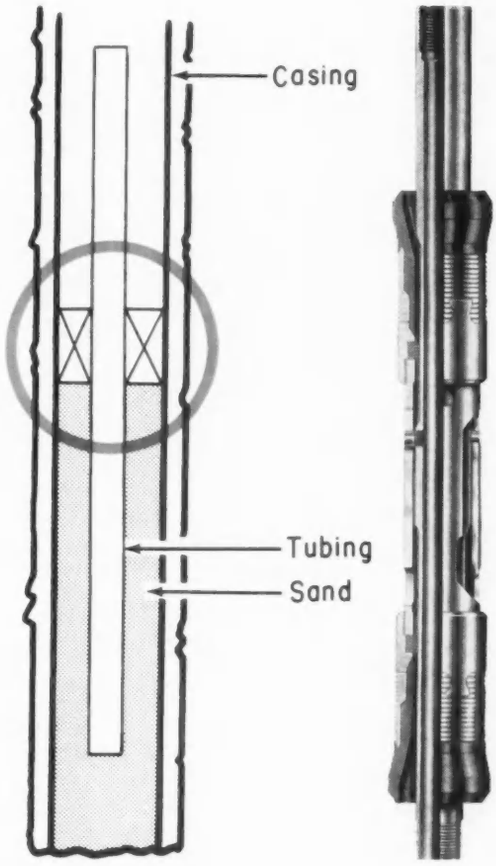


FIGURE 22—Full opening hydraulically set packer with built-in torque jar and safety joint. A 20-foot neck is left above for fishing purposes. The perforated tail pipe is stuck tightly.

► **Second operation.** If the stem still cannot be rotated after making the cut, an attempt should be made to pull and jar the packer up the hole. However, this may not always be possible since the upper packing element becomes, in effect, a swab cup. Depending on the weight of the fluid column in the annulus, the packer is more or less restrained from any upward movement.

► **Third operation.** If jarring fails to produce the desired results or snaps the stem in two at the upper connection, a tungsten carbide rotary shoe should be used to burn over the top seal and slips. This releases the packer from the wall of the casing so that an overshot can be used to latch onto the upper stem and retrieve the entire assembly from the hole.

In fact, since washing over with a tungsten carbide shoe is the surest method of all, there is a question as to why it is not used in the first place, eliminating the jarring run altogether. There are views both for and against.

However, the jarring method is the most economical if successful. It requires only one trip, no wash pipe is needed and the packer is retrieved intact.

The washover method requires two trips, the rental of washpipe and generally damages the packer beyond further use.

The chances of retrieving the packer by the jarring method are good and, while it is not as certain as the washover method, the temptation to try and save the difference in cost is often overwhelming. Consequently, the jarring method is almost universally the first approach in retrieving production packers.

In the above case, a tungsten carbide rotary shoe was used instead of a junk mill. This choice was made because a fishing neck remained above the packer after the jarring operation. After washing over the packer, it is an easy matter to go in with an overshot and latch on to the fishing neck above the packer.

If no fishing neck had remained for grappling purposes, a tungsten carbide junk mill would have been used to remove the packer by milling it up completely.

If a carbide rotary shoe were used to washover the packer, it would be necessary to go back with a spear and recover the packer. To insert the spear into a packer that has been washed over often is difficult and many times is unsuccessful. The freed packer has an uncanny way of falling to bottom and laying over to one side of the hole so the bore is inaccessible.

Case C. Full-opening hydraulically set packer with built-in torque jar and safety joint is stuck in 7-inch, 29-pound casing at 7,800 feet. 2½-inch tubing has been parted with an acid cutter above the packer leaving a 20-foot neck for fishing purposes. Stem of packer cannot be rotated or reciprocated to release, indicating that the perforated tail pipe is stuck tightly (Figure 22). This packer is completely drillable.

Fishing operations

► **First operation.** Since the stem cannot be rotated or reciprocated for releasing purposes, the inside of the stem and nipple should be drilled and washed out to a point several feet below the packer with a diamond point bit.

► **Second operation.** Make an inside cut just below the bottom of the packer, freeing the packer stem from the tail pipe.

► **Third operation.** Go back with a jar and overshot combination. The overshot should be equipped with lip guide, mill and tubing packoff assembly and attempt to rotate the lugs on the packer stem out of the jay or set position so that the packer bypass can be opened by reciprocation, thus equalizing pressures from above and below. The equalizing of pressures will allow the packer to be released and moved uphole.

► **Fourth operation.** If the packer stem cannot be rotated or reciprocated after latching the overshot, jar the packer until the lugs in the jay slot of the packer are sheared, permitting removal of the packer stem from the hole.

► **Fifth operation.** Make up string as follows:

- 5⅞-inch hard formation rock bit with cutter geometry to cut over its entire bottom surface, eliminating any undrilled ridges
- Fourteen 4¾-inch OD drill collars
- Enough 3½-inch drill pipe to complete string.

Proceed into the hole until contact is made with the top of the packer. The large diameter bit provides mini-

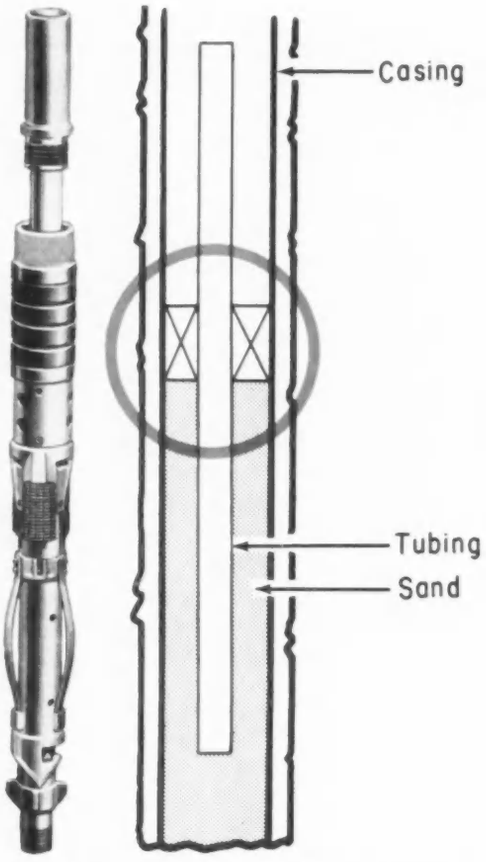


FIGURE 23—A 5½-inch multiple ring control head and circulating packer with release and dovetail slips is stuck so that the mandrel cannot be rotated or reciprocated.

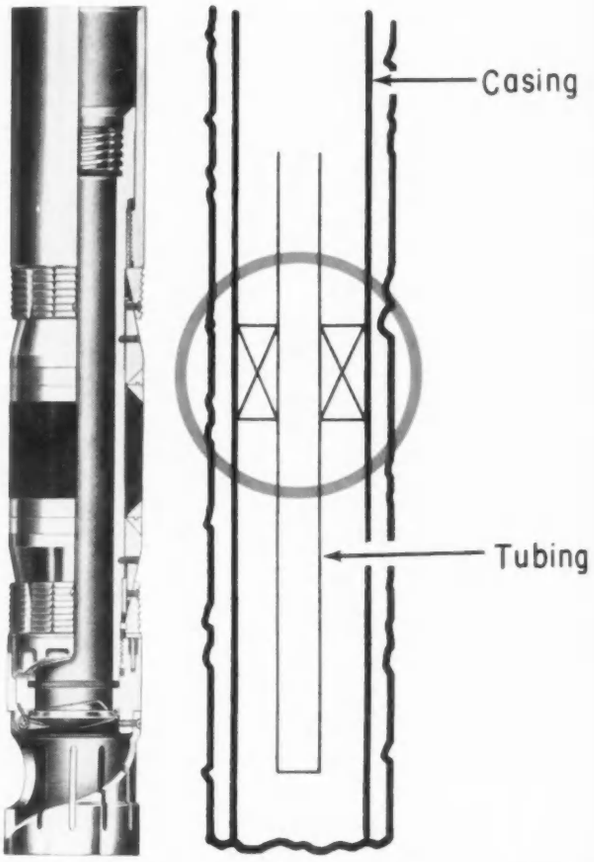


FIGURE 24—A permanent production packer is stuck so that the production string cannot be withdrawn from the well.

mum clearance in the casing, insuring that the bit will not have a tendency to drill off center and sidetrack.

Using normal pump pressure, set down lightly on the packer, and apply from 2,000-4,000 pounds weight at rotary speeds of 75 to 120 rpm. After drilling about 6 inches, the direction of the bit will be more or less stabilized and weight may be increased to 10,000-20,000 pounds. This packer is only 53 inches long and should be drilled up in from 3 to 5 hours.

Case D. 5½-inch multiple ring control head and circulating packer (Figure 23) with J release and dovetail slips is stuck so that the mandrel cannot be rotated or reciprocated. One joint of 2-inch tubing is left above the packer. Thirty-foot tail pipe below packer is stuck tightly.

Fishing operations

► **First operation.** Using a diamond point bit and little inch pipe, wash out the inside of the packer stem to a point about 5 feet below the bottom of the packer.

► **Second operation.** Make an inside cut just below the packer.

► **Third operation.** Go back with an overshot and try to pull the packer loose. Caution should be exercised in the pulling operation, since the packer stem should not be strained beyond the yield point. This packer is composed of a number of parts and if the stem is parted below the top of the packer, then the recovery of the many individual parts would present a somewhat complex problem, perhaps requiring many trips to solve. The strain on the packer stem in this case should not exceed 50,000 pounds.

► **Fourth operation.** If pulling is unsuccessful, go in with a tungsten carbide burning shoe and washover the packer, freeing it from the casing.

► **Fifth operation.** Recover the packer with an overshot.

Permanent production packers. The permanent production packer differs from the hookwall packer in that the stem and tail pipe are not mechanically linked to the barrel of the packer. These elements are connected only to the tubing string and hence may be withdrawn from the packer and well at any time without affecting the packer's efficiency. When the stem and tail pipe are removed, a flapper-type back-pressure valve, built into the lower part of the packer, seals off the packer floor and the casing above the packer from formation pressures.

The packer assembly itself is not retrievable and is designed to remain in the hole permanently, performing both the functions of a production packer and of a one-way bridge plug. The packer assembly is completely drillable.

Case A. Seven-inch permanent production packer (Figure 24) is stuck so that the production string cannot

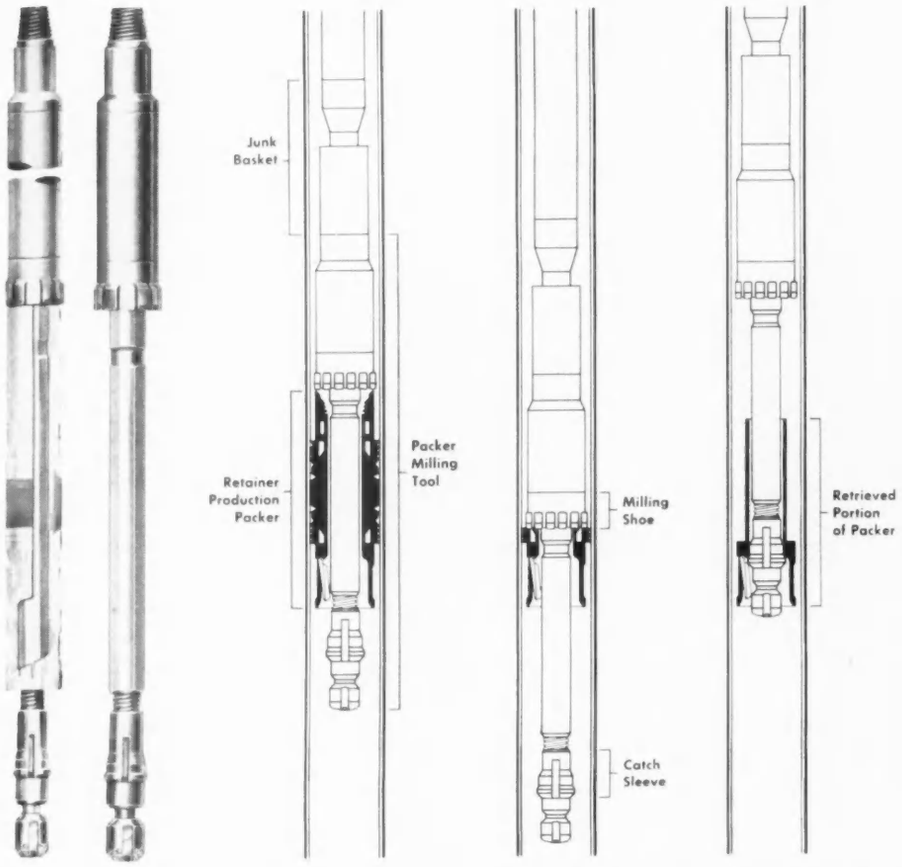


FIGURE 25—Shown at left are packer milling tools used to mill up the permanent production packer.

FIGURE 25A—Operational view (right) of milling and retrieving the packer.

be withdrawn from the well. Below the packer, a 30-foot production tube with a 20-foot perforated extension is stuck tightly. One joint of tubing is left above the packer for fishing purposes.

Fishing operations

► **First operation.** Attempt to jar the stem and tail pipe out of the packer with an overshot-jar combination.

► **Second operation.** If unsuccessful, use a diamond point bit on little inch pipe, drill and washout the ID of the stem and tubing to bottom.

► **Third operation.** Go back with inside cutter or acid cutter and make a cut five feet below the packer. Retrieve the cut portion from the well, jarring it out if necessary.

► **Fourth operation.** Use a packer milling tool (Figure 25) which can be run on drill pipe or tubing. A junk basket and at least one drill collar should be run between the packer milling tool and the drill string.

With the pump on, run in and tag the packer lightly. Set down with about 5,000 pounds, then take a 15,000-pound strain to check the operation of the catch sleeve. The milling operation is normally achieved with full circulation from 5,000 to 10,000 pounds of weight on the drill string and rotary speed of 50-75 rpm. Figure 25A shows the operational view of milling and retrieving the packer. The milling tool is designed to mill over a packer and retrieve in one round trip.

The packer milling tool can be released from the packer by holding a 5,000 to 10,000 pound strain on the drill string and rotating to the right until the catch sleeves collapse.

After the slips have been milled, the packer body is held in place by spring loaded catch sleeves and retrieved to the surface.

The permanent type packer was originally designed to be drilled up with a rock bit, circulating as many cuttings as possible out of the hole. This is a fast method of recovery, and in cases where a packer retrieving tool is not available is the most economical approach, especially if no equipment, (such as a second packer) is set (Figure 26) below the first, which might be adversely affected by cuttings or junk from the drilling operation. Even under good drilling conditions, all cuttings will not be circulated out of the hole. There always are some large fragments which break off during the drilling operation and move downhole, sometimes affecting the normal operation of the equipment below.

If there are no installations below the packer and if production will not be adversely affected by the remaining pieces of the packer which will be left in the hole, drilling offers an economical solution.

Proceed as in Operation 5, Case C, to drill up the packer. After drilling past the slips, the remainder of the packer will begin to rotate with the bit and this portion must be pushed to bottom.

Instead of a rock bit, a tungsten carbide packer mill or junk mill may be used with equally satisfactory results. In all cases, the packer should be disposed of in 2 to 5 hours.

Multiple production packers. Economics have dictated the use of multiple strings of tubing for producing several zones of production.

Naturally, the easiest solution to a fishing job for multiple completion packers is to avoid the necessity for such an operation; but as with any item run down the hole, an occassional fishing job is inevitable. It is possible to minimize the frequency of such an occurrence through proper planning and preparation before running the equipment.

It should be noted that optimum conditions for retrievability are coincident with optimum conditions for "fishability." That is, an installation which minimizes the chances for a fishing job also is easier to fish out should it become necessary. Well should be clean. More fishing operations and more down-hole equipment failures have been caused by "junk" in the hole than any other reason. Also, because of the occurrence of "junk," the fishing

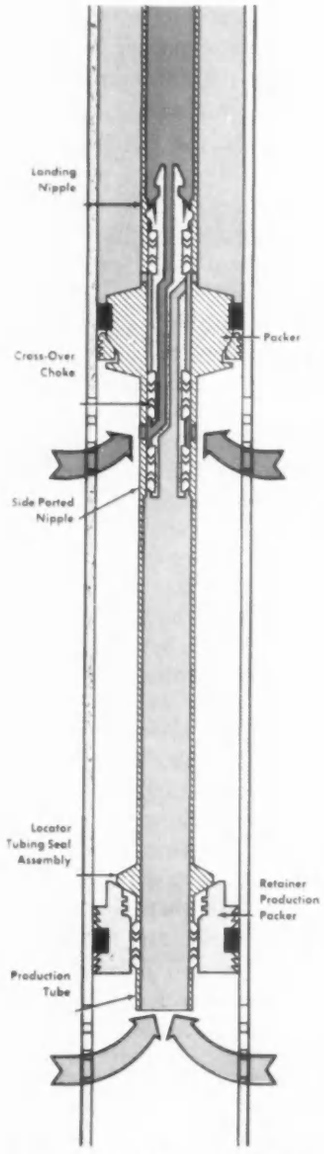


FIGURE 26—Schematic drawing showing two production packers in the same well.

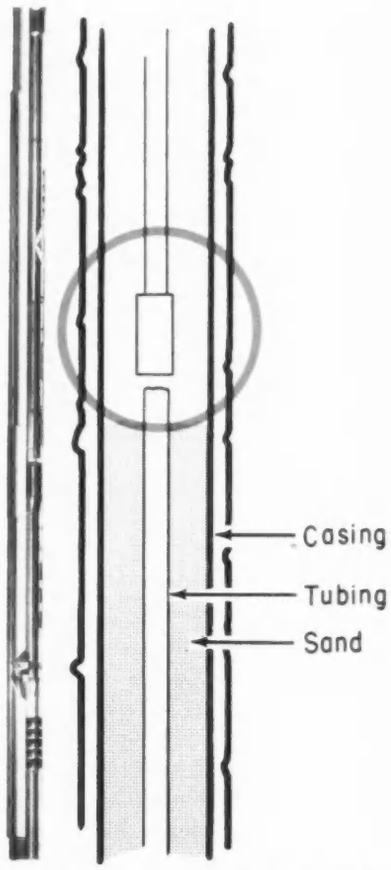


FIGURE 27— Tubing is stuck because of a sanding or mud condition necessitating the use of a washover recovery technique.

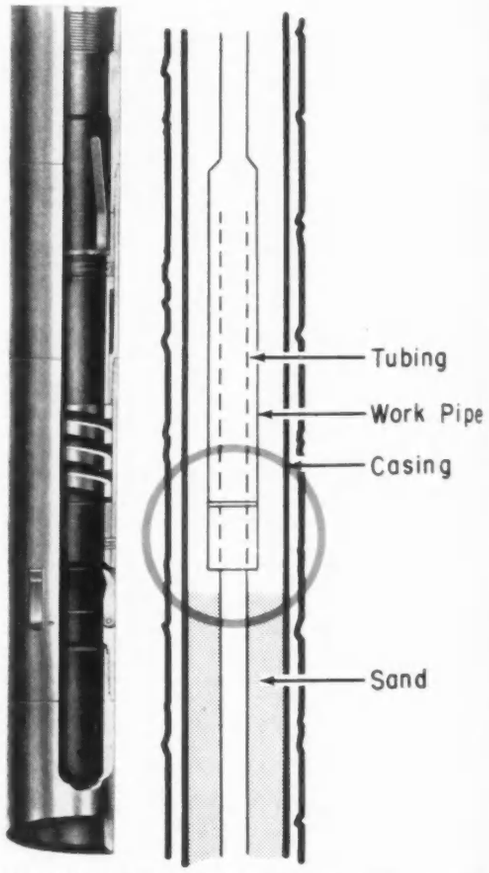


FIGURE 28—Typical hydraulic (pump pressure) outside cutting tool.

jobs are quite often more difficult. This junk will consist of rubber and metal from "drilled-up" bridging plugs which for some unexplained reason are not circulated out of the well during the drilling and mud conditioning operations. Every effort should be made to clean up the well before running the packers.

Proper design and installation. The design and installation of the multiple completion bottom hole equipment should be carefully considered to eliminate any undue complications if a fishing operation should ever arise.

The safety joint should not be placed below the producing perforations where it is apt to be covered by sand or solids from the formation and thereby rendered inoperable. Also, in multiple strings, stagger the safety joints so that no two of them are at the same depth (a minimum of four feet separation). The uppermost safety joint should be on the string that will be retrieved or picked up first, and other safety joints should be placed in similar order down the hole.

A pup joint (minimum 4-6 feet in length) having an ID equivalent to the minimum restriction in the string above the pup joint, should be placed in each string of tubing below each packer. This provides a place for cutting the tubing with a properly sized tool, thereby aleviating the difficult job of going through a restricted ID and cutting in a larger tubing section.

Packers with straight through openings (as compared to concentric flow channels) will allow the running of a macaroni string through a packer to wash out on top of packer below to facilitate retrieving. Of course, this depends on the size of the opening through the packer and is often limited by the space available to provide an opening of sufficient diameter.

Fishing operation. Sand or other material may have settled out on top of the packer causing it to be stuck. A string of tubing should be run to the top of the packer to circulate out this material. After washing out to the top, an attempt to release and retrieve the packer in the

normal manner should be made. Since there are several different types of releasing mechanism, a discussion of each will not be possible.

If the packer is still not rerievable, the tubing string should be cut below the packer (previous techniques discussed), and another try should be made to pull it.

If this operation is not successful, the tubing above the packer should be cut leaving enough tubing to latch onto with an overshot. Then run in with a crushed carboloy rotary shoe and, mill over the packer and the slips.

The packer can then be pulled with an overshot, or a spear if insufficient tubing is left for an overshot.

The fishing for triple, quarduple and quintriple packers should follow the same principles as discussed above for dual completions.

RECOVERY OF TUBING

Fishing techniques for recovering tubing will vary with the conditions which caused the tubing failures. These conditions include:

A. When the tubing is weakened by corrosion, erosion, or abrasion and is pulled in two while trying to retrieve the packer or pull the tubing.

B. Where tubing is stuck due to a mud or sanding condition.

C. When the down hole equipment is larger in diameter than the tubing (gas lift mandrels) and the tubing or bottom hole equipment has failed due to erosion, corrosion or abrasion.

D. Collapsed casing which causes an obstruction and prevents pulling the tubing.

Case A. Pipe weakened by corrosion, erosion or abrasion and is pulled in two while trying to retrieve the tubing. The tubing has parted, leaving a jagged top looking up. The failure was caused by corrosion and the annulus was clear of sand or heavy mud.

Operation. Pull the free tubing above the failure point. Return to the bottom with an overshot and engage the fish. Run a free point indicator with a chemical cutter and, after establishing the free point of the remaining tubing, cut the tubing. Remove wireline from hole and pull the free tubing.

Case B. Where tubing is stuck due to a mud or sand condition.

Washover and recover cutter method. This method includes use of wash string with a washover and recover cutter located immediately above or one joint above the rotary shoe (Figure 27).

After washing over the fish to the desired depth, the rotary shoe is picked up about 15 or 20 feet off bottom. Then, while the string is being slowly raised, right hand rotation is begun causing the slips to move into the catch position. The cutter is raised until the slips engage the joint or collar. If, the fish is flush-jointed pipe, the slips will engage and grip the pipe at any point.

To determine if the fish is securely caught, a strain of 15,000 to 20,000 pounds above the weight of the string is applied. Tension is then slacked off until the indicator shows about 2,000 pounds above the string weight plus fish weight. The cutter is rotated to the right at 18 to 36 rpm the pipe is cut in 1½ to 2 minutes. The fish is brought to the surface and stripped out of the wash pipe

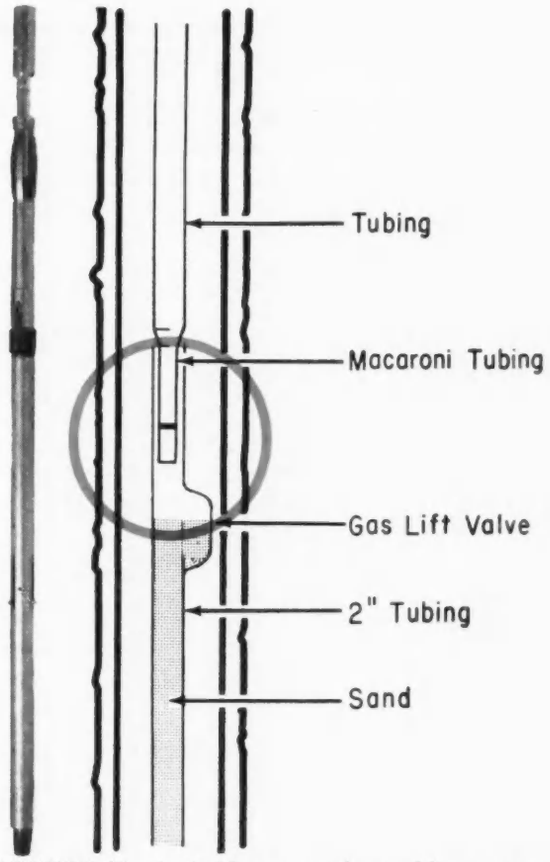


FIGURE 29—An inside type cutting tool is necessary if downhole equipment is placed on the tubing restricting the use of tools for outside cutting or washover operations.

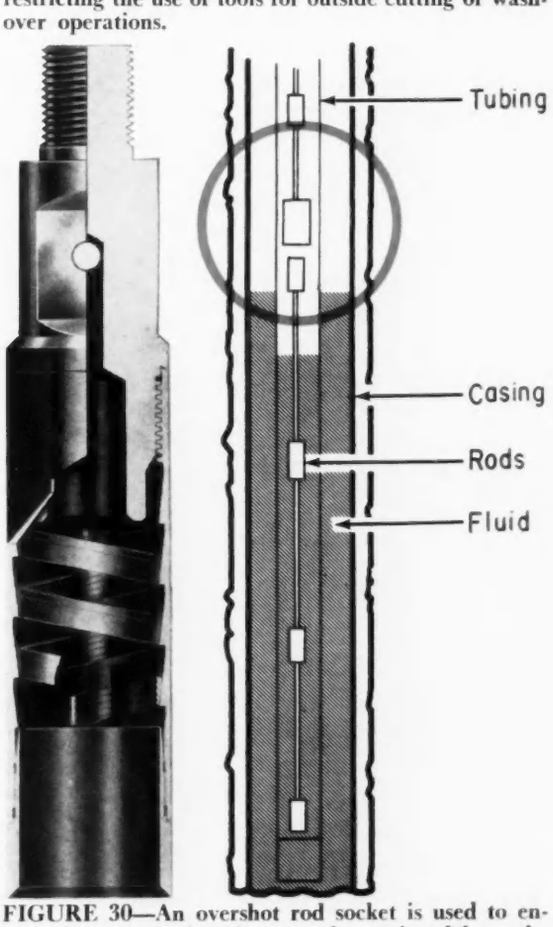


FIGURE 30—An overshot rod socket is used to engage the rods so that they may be retrieved from the hole.

which is left hanging in the slips. The tool may be lowered for another cut, never having been brought out of the hole.

Hydraulic (pump pressure) outside cutter (Figure 28). After the washover has been made and the wash pipe has been pulled from the hole, remove the rotary shoe and install the hydraulic outside cutter in its place. This tool is recommended for external flush or slightly upset collar-less tubing.

Run in the hole to the desired cutting depth. Rotate the wash pipe to ascertain any undue friction. If found free, apply pump pressure slowly, rotate wash pipe and increase pump pressure to approximately 200 psi. The cutter then should be in operation. This condition will be indicated at the surface by a slight slowing of rotation. Approximately 1 to 2 minutes is required to accomplish the cut. It it is undesirable to proceed with the cut after positioning the cutter over the fish, pull up slowly until the cutter shucks from the top of the fish.

Case C. When down-hole equipment is larger in diameter than the tubing (gas lift valve mandrel) and the tubing is sanded tightly below the gas lift valve.

Inside cutting method. When a string of gas lift valves (external diameter too large to wash over) becomes sanded up, there is no satisfactory method of washing over and recovering from the outside. The only practical approach is to recover the pipe by an "inside" method.

Since the tubing is stuck tightly below the gas lift valve, it is impossible to go in with a jet washdown tool and string shot and back off below the valve. Cutting and pulling offers the most economical solution.

The tubing above the gas lift valve is backed off and retrieved. A short string of macaroni tubing is attached to the end of a string of plain tubing, along with the inside cutting assembly. This small string should be long enough to reach below the gas lift valve mandrel.

Operation. The cutter, with diamond bit and guide assembly is lowered into the well. As the tool approaches the fish, the string is rotated and lowered slowly. The guide shoe contacts and passes over the top of the fish centralizing the tubing within the guide assembly (Figure 29).

The guide assembly is secured to the fishing string by a shear pin. When the guide shoe contacts the formation or other obstruction, the pin shears disengaging the guide assembly from the fishing string so that the cutter and assembly may be lowered independently into the fish. When the bit contacts sediment or bridges, begin circulating and rotate.

After cleanout to the desired depth, the cutter is rotated slowly and picked up. The slips set automatically and a cut is made in from 2 to 4 minutes. The knives are fed into the pipe by spring pressure alone and are independent of the upstrain from the rig floor.

If necessary, the cutter may be released by simply lowering the fishing string. This retracts the knives and releases the spear slips, allowing the tool to be reset at another point in the tubing or brought out of the hole.

Another technique is to run one short joint of macaroni (10-15 feet) with a diamond bit. Wash tubing out below gas lift valve.

Put cutting tool on bottom with macaroni joint between the cutting tool and spear, and return to the fish. A shear pin guide is used to guide the assembly into the fish. As soon as a collar is contacted, the shear pins will be sheared and will allow the cutting tool to enter the fish.

Lower in until bumper ring bumps up on top of the fish to establish true depth. Pick up enough to remove the spear from the fish and position the cutter at the proper depth in the fish to make the cut.

When the cut has been made, pick up slightly to close the cutter and retract the knives. Slack off until the bumper ring on the spear "bumps up" on the collar. Make sure the spear is in the catch position and pull the fish.

Case D. Collapsed casing which prevents pulling tubing.

This casing has collapsed to the extent that tubing collars will not pass through the restricted interval.

Go in and chemically cut the tubing above the collapsed casing, allowing the tubing to drop to bottom. Return with a "casing roller" and roll the casing out to the normal internal diameter. After the casing has been enlarged, return to the top of the tubing with an overshot assembly and pull the remaining tubing.

RECOVERY OF RODS

It is necessary to fish for pumping rods because:

- Rods have backed off
- Rods have crystallized and parted
- Rods have been sanded up and are unable to be pulled.

If rods have backed off or broken due to crystallization, pull out the free string of rods and return to bottom with a rod socket which is regular field equipment for recovery of such failures. Latch on to the rods and pull the remaining portion of the string out of the hole.

If rods have been sanded up and cannot be recovered by the field personnel, of course, fishing is inevitable. Pull the tubing and strip the free rods and tubing until the sanded interval is reached.

Then, back out the rods and the tubing separately. Continue this operation until the entire length of rods have been recovered.

Be sure that the tubing is not separated. If it is indicated at the surface that a parting condition of the tubing exists, return immediately to the original position before rods are allowed to "spill out" and "wad up" in the open casing.

If this situation does occur, run a center rope spear on tubing with heavy "barbs" and equip the upper end of the spear with a stop (diameter of stop is ½ inch less than inside diameter of casing). Push spear downward so as to compress the loose rods in a more condensed interval. Upon an upward movement, "barbs" will catch hold of the rods and are then retrieved to the surface.

If, for any reason, it is not practical to pull tubing to recover rods, a left hand threaded macaroni string must be used. The swivels and all fishing tools are also left hand threaded.

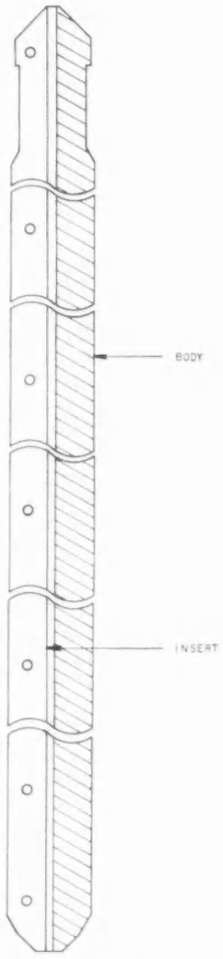


FIGURE 31— A slotted tubular "go devil" is used to assure that a rope socket is looking up to provide for a fishing neck.

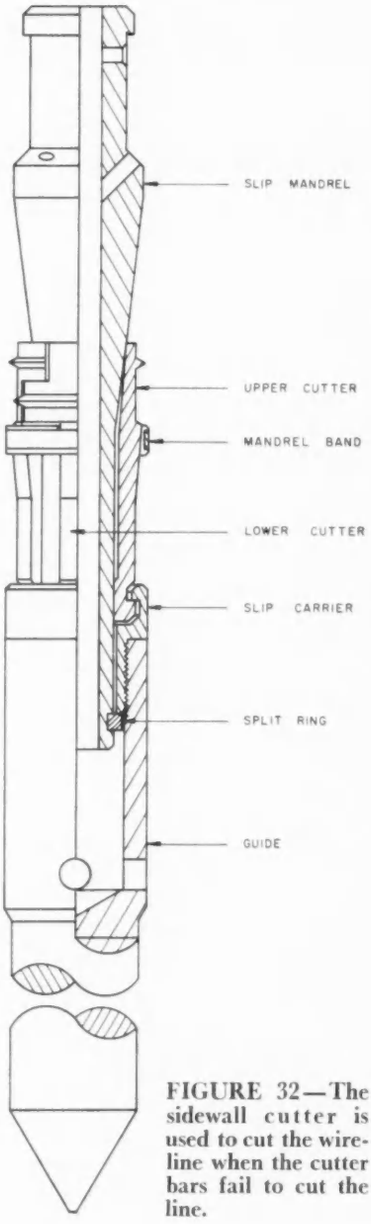


FIGURE 32—The sidewall cutter is used to cut the wireline when the cutter bars fail to cut the line.

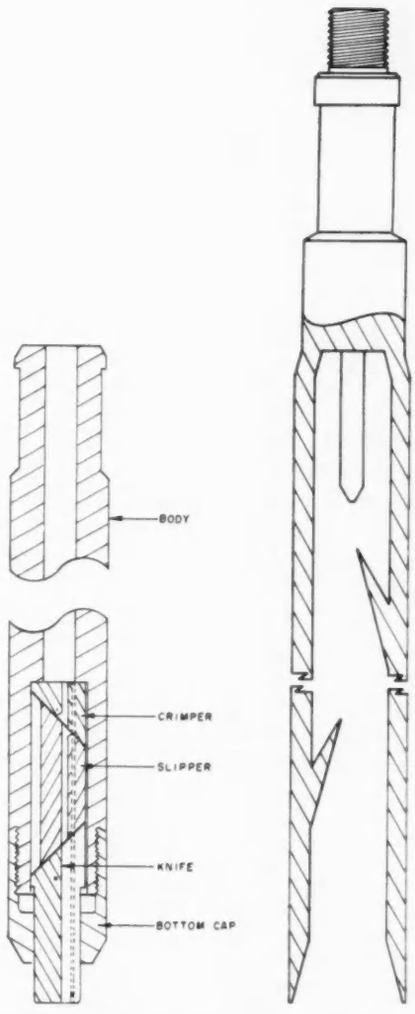


FIGURE 33—A wireline snipper is used to cut the line at the rope socket.

FIGURE 34—A wireline grab is used to retrieve line and tools if the line should break going in or out of the hole.

The most common tool to engage the rods is the rod socket (See Figure 30). When the fish is irregular or distorted, the box tap is used to engage the fish rather than the rod socket.

It is possible to wash down and around the fish prior to latching on to it. After firmly engaging the fish, exert a steady pull until the rods are pulled free. Then pull and brake out the entire length of rod string.

RECOVERY OF WIRE LINE TOOLS

Most wireline fishing jobs result from equipment malfunctions or unfavorable well conditions. A successful fishing operation requires careful planning, patience and good judgment.

Where wireline and tools are stuck or lost in a well, the wireline should be retrieved from the well first, followed by service tools and other equipment. To fish the line and tools separately, the line should be cut at the rope socket.

Wireline cutting. There are various methods of cutting the wireline at the rope socket. The most common method is the dropping of a "cutter bar" alongside the wireline.

A "cutter bar" consists of a wireline stem section with a rope socket attached to the upper end and a blind box to the lower end. The rope socket provides a fishing neck to the cutter and the lower blind box cuts or kinks the line as it strikes the top of the rope socket. Different sizes of blind boxes are used, depending upon the size of the tubing. Recommended are a 1½-inch OD blind box for cutting wireline in 2-inch tubing and a 1¾-inch OD in 2½-inch tubing. Length of stem between the rope socket and blind box is determined by well conditions and type of equipment in the well. If the tubing string includes side pocket mandrels, the stem must be of sufficient length (5 to 6 feet) to pass through mandrels without lodging. Dry gas wells require a shorter stem section (3 feet) to reduce the weight and impact.

Knuckle joints are recommended in wells with crooked tubing. This allows more flexibility of the cutter. The cutter bar can be dropped if the end of the line is in the hole or if the wireline unit is still attached to the line.

However, if the unit is still attached to the line, the line should be left slack after the cutter bar has passed through the Christmas tree.

Cutter bars are dropped only when one is reasonably sure that a wireline rope socket is "looking up." However, if the tools have been blown up in the hole by pressure differential or if sand or junk is present on top of the tool, the slotted tubular "go devil" technique should be used (Figure 31).

A slotted tubular "go devil" is placed around the line and pinned in position. It is then dropped in the tubing and will slide down the line and fall on top of the tools or objects. The "go devil" is provided with a slotted rope socket on top. This assures the operator that a rope socket is "looking up."

The "go devil" is also used where the mechanical jars are stuck in the open position. The impact of the "go devil" on the jars will close the jars. With the "go devil" on bottom, a cutter bar can then be dropped to cut the line. If the cutter bar fails to cut, the wireline should be manipulated in an effort to cut the line. If jars are operating, downward jarring usually helps in kinking and cutting the line. If unable to break the line, another "go devil" should be dropped, followed by another cutter bar.

A sidewall cutter (Figure 32) is another method of cutting the wireline and usually is used when the cutter bar fails. The sidewall cutter consists of a tapered mandrel and is mounted on cylindrical cutters that expand against the wall of the tubing. The sidewall cutter is attached to the wireline tools with a running tool and is run alongside the line lost in the well. When the cutter lands on the bottom, downward jarring will expand the cylindrical cutters against the wall of the tubing, cutting the line and shearing the pin in the running tool. The operating string is then pulled slowly out of the well to the surface. The side wall cutter is retrieved after the line above is removed from the tubing.

A wireline snipper (Figure 33) or a 5-foot "go devil" with a 45-degree taper on the bottom can be used to cut the line at the rope socket either in the tubing or in the casing below the end of the tubing.

The slotted 5-foot "go devil" is placed around the line and dropped from the surface. The "go devil" travels along the line and upon contact with the wireline rope socket on bottom, the line is cut through by the scissoring action of the tapered end.

The wireline snipper is attached on a wireline in a similar manner as the "go devil" and allowed to slide down the line. When the cutter hits the tools, the impact shears a pin which allows a tapered knife section and snipper to move together, thus cutting the line. This same action crimps the line between the crimper and snipper and permits retrieving the tool with the wireline.

Where a line breaks going in or coming out of the hole and the tools are free, the line and tools can be fished together. The end of the line should be located and latched with a wireline grab (Figure 34). If the wire and tools are stuck and will not free after continuous jarring, the grab should be jarred down the hole approximately 10 feet. This will usually kink the line below the grab. Then, by jarring upward, the line should break clean. After retrieving the broken end from the well, the line should be cut at the rope socket and fished separately.

Locating the end of the wire. Estimating and locating the end of the wire are two of the most important steps in planning a succesful fishing job.

The depth of the end of the wire is estimated in the following manner:

- Estimate the depth that tools should stop or fall back
- Record the counter reading
- Estimate line coil—.082 and .092 will coil approximately 3 feet per 1,000 feet in 2-inch tubing and approximately 5 feet per 1,000 feet in 2½-inch tubing
- Record the line stretch and the point at the surface where the line parted. Thus, the formula for estimating the end of the wireline is:

End of line depth of tools = counter reading — line stretch + distance from stuffing box to point on surface where line parted—line coil.

After the depth of the end of the line has been calculated, it is accurately located with the wireline tools. A wire finder usually is run to locate the end of the wire. When the line is located, a light downward jarring will kink or ball the line so that a wireline grab can then be used to hook and retrieve the line.

Fishing wireline. Before running the wireline grab (Figure 34) in the well, the wireline blowout preventer should be tested in the closed position. The wire line grab is flexible in order to bend the tool to its full gage before running. A common practice is to bait the wireline grab with either soft line or wire to limit the possibility of passing the end of the wire. When fishing at shallow depth, soft line should be used; at greater depths, wire is recommended.

The wireline grab is run in the well and upon contact of the end of the wire, light downward jarring usually is sufficient to securely wrap the wire in the barbs of the grab. The line may then be pulled to the surface.

When the wireline grab and line is pulled into the lubricator, the blowout preventer is closed on the line and pressure bled off the lubricator. The lubricator is raised and tied off in the up position, and a wireline fishing clamp is attached to the line on top of the blowout preventer. The broken line is tied to the line on the reel and removed from the well.

Retrieving wireline tools. Standard pulling tools should be run to fish wire line tools. Accurate measurements of the tools should be recorded to assure that enough lubricator is used.

If the tools were blown up the hole and a "go devil" and cutter bar were used to cut the line, then the cutter bar and "go devil" should be retrieved. A lead impression block will determine if there is any wire on top of the tools.

If there is wire on top of the tools, a wireline grab is run to remove the wire above the tools. After retrieving the wire above the tools, return to bottom with another impression block. If it indicates that the rope socket is clear of wire, a standard pulling tool is run and the tools removed from the well.

If the impression block indicates that the tools are tangled in the wire, a 1½-inch blind box and a 5-foot stem is run below the jars. Downward jarring usually will drive the tools through the wire leaving the wire on top of the tools. The wire is removed and the tools are retrieved.

Coming Next Month

PART 2 of the Engineering Practices Manual on Current Oil Industry Fishing Techniques and Tools will be presented in the September issue of WORLD OIL.

This part will discuss fishing in open hole and will include:

A. Recovery of drill pipe

1. Free point-string shot method
2. Washover back-off connector method
3. Outside cutting method

B. Recovery of drill collars

1. Drill collar spear method
2. Taper tap method

C. Recovery of twist-off drill pipe

D. Recovery of small objects

E. Recovery of miscellaneous wireline tools, logging devices, etc.

Streamline paperwork—and put $$ in the till

To get a true view of the high cost of business forms, it is necessary to study all costs involved

By Joel C. Culley, Forms Analyst
Service Pipe Line Co., Tulsa

OIL AND GAS companies are plagued with unnecessary, duplicate and inefficient paperwork.

What is causing this profit-devouring operation?

For one thing, most businesses are operating without clearly defined objectives, resulting in accumulated and compounded paperwork—a large portion of which is of questionable value.

Annual cost soars. To get a true view of the high cost of business forms, it is necessary to study all costs involved. Briefly, paperwork costs include forms, purchasing, printing, stocking, ordering, issuing, preparing, distributing, filing, storing (temporary then permanent), and the eventual destruction of the forms.

Printing the forms is only one of the costs. For every $100 worth of forms purchased, it may cost a company $2,000 to $4,000 to use the forms. Whereas, in 1900 one clerical worker was able to handle the paperwork for 30 production workers, the ratio now is reported to be as low as one clerk to one worker.

An example of how ridiculous the paperwork problem has become is illustrated by one of today's modern jet-liners and its inability to lift from the ground the weight of the paper necessary for its manufacture.

Needed is tighter control. Business cannot get rid of paperwork. But it can control it.

To reduce costs and increase profits, proven controls and specific standards must be established by management, which must instigate the program and place it with competent, professional systems personnel who will conscientiously carry it out.

One major problem is the inability of executives to keep up with all reports they receive. The answer to this is simply to eliminate unnecessary reports and revamp the necessary, but inefficient ones.

Many companies have recognized the merit of "exception" management reporting, i.e., each report shows exceptions to a situation rather than the usual that may occur month-in and month-out. Obviously, normal or near-normal operations do not call for executive action—abnormalities or exceptions do.

Destroy 'paper empire.' If management is to live up to its responsibility of providing as much profit from an enterprise as possible, it must support a paperwork program—and it must thoroughly understand the objectives and appreciate the results. This attitude can, without ill will, bring about the raising of paperwork empires which have been in existence for years throughout a company. Most paper empires are built for two reasons:

1. **Every employe wishes to feel important.** He may satisfy this yearning by surrounding himself with self-invented, but unnecessary and inefficient paperwork. If, on the other hand, management expresses a desire to streamline paperwork, these same individuals will reverse their actions, but still feel important because they have management's blessing and appreciation.
2. **If an employe is not sure of management's policy concerning the amount of detail to be included in records, he may protect himself by accumulating needless data or "alibi" paper.** And he may keep it forever. But, if management clearly states that it wishes just so much detail and no more, employes probably will

heave a big sigh of relief and join the cause.

Another important aspect, called records management, is a destruction schedule of records that have outlived their use. Records in storage require floor space, storage equipment and personnel to organize and care for them.

Forms and birth control. Forms control, a modern systems device, is one of the simplest and best methods for cutting paperwork.

A form is defined as a piece of paper containing business data. This covers all paper used in the operation of a business and is not necessarily a printed form, but includes all handwritten or machine prepared reports.

"Birth control" is the obvious way to prevent needless data.

This means the thorough examination of a form to determine if it is needed. If it is not, stop it before it starts. If it is, refer to a "functional forms index" to see if an existing form contains all or most of the needed data. (A functional forms index is a listing of all forms by their use, not their titles or form numbers.)

If there is such a form, new data may be added. This may also prevent more than one group from compiling and recording the same information.

Proper design cuts cost. Forms design, when properly applied, can improve any form.

Good forms design requires a knowledge of use, how and under what conditions the form is to be prepared, related forms, all business machines (capabilities and limitations), papers and carbon papers, multipart form make-ups and clerical time savers.

Also, it is helpful for a form designer to have a slight "Rembrandt complex." This talent will add attractiveness to an efficiently designed form. Simple but adequate instructions about preparation and disposition should be added to the form.

If study and care are devoted to the design of a form, savings in the purchase price and use of the form may result.

Physical forms standards can bring immediate savings in printing and paper costs. Specifying standard sizes will save paper costs and money on many other items.

Besides causing waste when cut from stock sizes, odd-sized forms often require special machine accessories, special envelopes, special binders or ledgers, and special storage equipment.

Further savings can result from specifying paper qualities that are adequate, but not expensive. It is just as important not to use paper of inadequate quality.

Printing and stationery control. Printing controls will not solve the problem of "bootleg" (unauthorized) forms. It can even have the adverse effect of driving the "moonshiners" underground. They have been known to draw these forms by hand when all other means have been refused.

The best approach is to sell personnel on the forms control program as a service to all.

Stationery controls can reduce many of the forms-cost areas. Accurate records of forms issued will indicate the number of forms used in a given period.

The quantity of forms purchased at any one time required careful analysis. If order quantities are set too high, the stationery department will soon run into a shelving-space shortage and may be risking the loss of thousands-of-dollars worth of forms due to obsolescence.

But, money can be saved through volume buying. A survey from the Business Forms Institute shows that one and one-half to three times as many forms per purchasing dollar may be had when they are purchased on a volume basis.

This does not mean that costs can be cut by automatically increasing every order. Certain elements must be considered, such as: How long will the form be used in its present state; what is the annual usage; and what is the storage life of the form?

Various departments using forms should be instructed to requisition not less than a three months' supply and not more than a six months' supply of most items. Strict adherence to this rule prevents too frequent requisitioning and warehousing of forms.

The safest way to take advantage of volume prices is to synchronize the ordering of many forms, all having the same physical specifications. Here again, standardization will bring about savings.

Temporary paperwork. Temporary for how long? There are undoubtedly a number of these 20-year-old temporary forms floating around most companies. They probably were originated for a special study or project. The only trouble is that nobody said to quit using them and no one knows why they are used. They should be abolished as quickly as possible.

Industry standardization of paperwork can make further savings and profits, and two advantages which may result are:

1. Clerical processing time will be reduced in departments that handle forms originating from many other companies. This is possible because of the standard terminology, standard positioning of data and standard size.

2. Cooperating companies may pool their form orders and share in the savings of volume buying.

The excessive paperwork problem can be solved by analysis, prevention, elimination, consolidation, and planning. None of these can be effective without continuing cooperation and solid backing of top management.

When thinking of paperwork, it should be remembered that more than the initial cost or purchase price is involved. Most forms, once created, will require a lifetime of care—from creation to cremation. **—The End**

About the Author

Joel C. Culley has been the forms analyst for 10 years in the Procedure Department at Service Pipe Line Company, a subsidiary of Standard Oil Company (Indiana). He is a graduate of the Spartan School of Aeronautics and served as an instructor there for two years. He attended the University of Tulsa in the fields of engineering and business administration, and has taught Forms Control and Design as a part of the Systems and Procedures course at the University. Culley is a charter member of the Tulsa Chapter of the Systems and Procedures Association and has served as vice president and secretary. He is general chairman of the 1960 Business Equipment Show of Tulsa, which is a joint project of the Tulsa Chapters of SPA and NOMA.

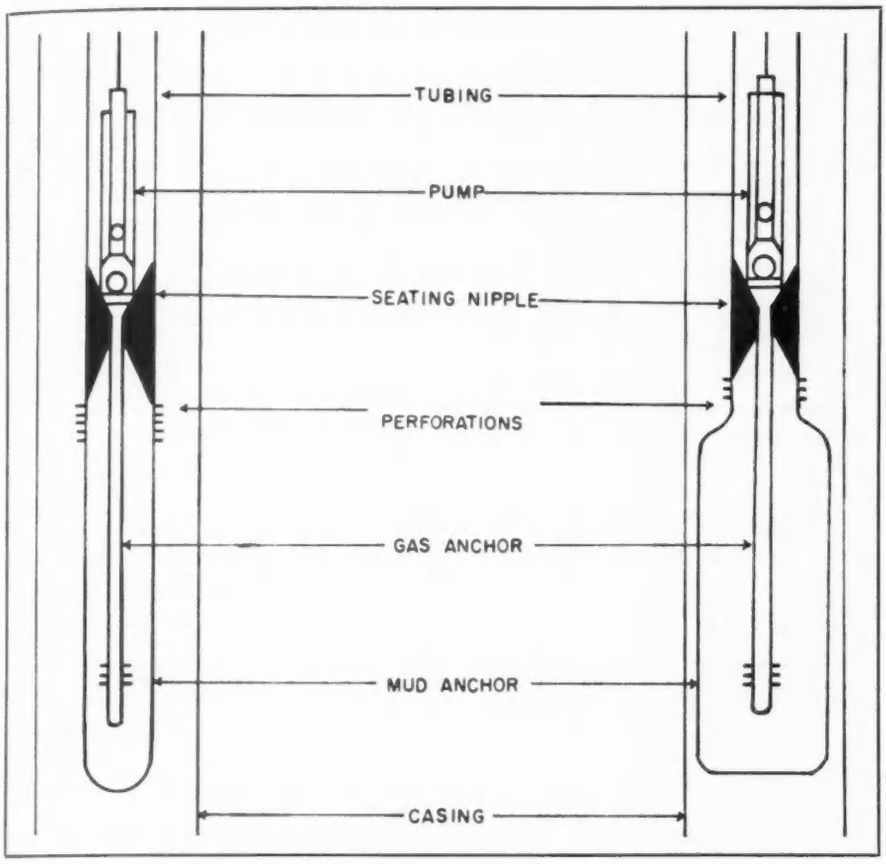


FIGURE 1—Here are two types of field-constructed gas anchor-mud anchor systems which are used to achieve downhole separation. Both have proven successful in the West Texas area. Left is standard gas anchor-mud anchor system. Right is standard gas anchor-oversized mud anchor system.

Field-constructed gas anchors can save money

Proper operational procedures combined with bottom-hole separation equipment, provide an economical solution for gas interference problems

By C. J. Merryman, Petroleum Engineer
Sun Oil Company, Midland, Texas

SUN OIL COMPANY has found correct application of field constructed bottom hole gas separator systems that will result in both increased pump efficiency and increased production. Field tests conducted in the West Texas and Southeast New Mexico areas (See Box) have proven and re-emphasized the merit and importance of gas anchor installations.

Gas interference is a common pump problem and many wells today produce less than capacity because the bottom hole pump and related equipment lack the design improvements necessary to handle gas and improve efficiency. This article presents several methods for locating, evaluating and correcting the gas interference problem. The scope of coverage is limited to discussion of wells and test data from the general area of West Texas and Southeast New Mexico, although the principles involved will apply to most oil well pumping installations.

Practically every bottom hole pump in oil field service is hampered to some degree by having to handle gas as well as fluid. Efficiency is reduced by the amount of free gas or liberated gaseous vapors that have to be pumped in the same manner as an equivalent volume of fluid. Corrective measures to eliminate or minimize gas interference depend on a thorough study and understanding of the mechanical, operating and fluid conditions that contribute to gas problems.

The majority of pumping well gas troubles is caused by free gas in the well bore, gas trapped in the fluid column and gas being liberated from solution by either agitation or pressure changes. When this gas is processed through the pump, efficiency is reduced by the volume of fluid the gas displaces in the pump operation.

Occasionally, when free gas enters the pump and occupies a volume equivalent to the plunger displacement, pump valves become locked shut. Under these circumstances the pump will fail to operate until a sufficient pressure exists within the pump to overcome the fluid pressure in the tubing and open the traveling valve. Frequently, such measures as re-spacing the pump, tapping bottom lightly or increasing pump speed will increase compression enough to break the gas lock.

The ideal method of eliminating gas interference would be to separate the free gas from the fluid and allow it to be vented through the casing annulus. The gas anchor serves this purpose by being a gas-fluid separator that uses gravity and agitation to separate as much gas as possible from the fluid prior to entering the pump.

Gravity separation is attained by using sufficient down-flow area to permit the fluid to flow downward at a lesser rate than the rise of the gas

These case histories show how improved operational procedures and installation of bottom-hole gas separators can increase production . . .

1. Well A, South Eunice Field, Lea County, New Mexico.
Tubing had not been pulled after completion, and the original pump installation was made one joint above the open end tubing anchor joint. Production test was 30 bopd and 12 bwpd. Dynamometer tests indicated gas interference. Rods and tubing were pulled and re-run with a bull-plugged mud anchor and gas anchor. Production test after well work was 40 bopd, 17 bwpd, GOR 2186, top allowable.

2. Well B, North Cowden Field, Ector County, Texas.
Well equipped with open ended tubing anchor joint. Production test was 43 bopd. Dynamometer test indicated gas interference. Pulled rods and tubing and re-ran with 60 feet of 2½-inch mud anchor and 30 feet of gas anchor. Production test after work was 76 bopd, capacity, and GOR 980.

3. Well C, Shannon-San Andres Field, Crockett County, Texas.
Well equipped with mud anchor and gas anchor. Production after workover declined to 50 bopd. Well weighing indicated severe gas interference. Tubing was lowered 30 feet. Production increased to 144 bopd.

4. Operator B, Harper & Foster Fields, Ector County, Texas.
The following examples show partial results of field surveys where the principles of improving operations and installing bottom hole gas separation systems were applied. Field constructed anchors were used in each well.

Well	Prod. Before	Improvement	Prod. After	GOR
A	10 #	Installed MA & GA	64 #	647
B	52 #	Installed MA & GA	93 #	654
C	53 #	Installed MA & GA	93 #	193
D	68 #	Installed MA & GA	93 #	1168
E	60 #	Installed MA & GA	93 #	739
F	20 #	Installed MA & GA, & Increased Time	65 #	NA
Lease G (14 wells)	557	Installed MA & GA & Increased Time	744	NA
Total	820		1,245	

= Capacity Increase 425 BOPD.

bubbles. The rate of rise for bubbles[3] has been determined to be approximately 6 inches per second in water. Rate of rise in other fluids is dependent primarily on the bubble size and the fluid viscosity.

The 6 inch per second rate was measured with a bubble diameter of 0.011 feet. Also, the rate of rise for bubbles of similar diameter in other test fluids having a viscosity of 1 to 15 centipoises (a viscosity range common to most West Texas crude oil) was approximately 6 inches per second. This data indicates that as gas separation becomes more critical, increased down flow area within the anchor system is beneficial.

Separation by agitation is achieved by reduced areas and increased flow velocity between the mud anchor and the casing, and by flow direction change and turbulence as the fluid is drawn through perforations into the mud anchor. Two types of field constructed mud anchor-gas anchor systems are shown in Figure 1.

Operation. Both anchors, standard and oversized, function alike. When fluid and gas rise past the anchor, a portion of the free gas separates from the fluid and rises up the annulus. As the pump draws fluid through the mud anchor perforations, additional gas is separated by agitation and is permitted to flow back into the casing annulus through the upper portion of the perforations. As the oil moves downward through the mud anchor-gas anchor annulus, additional gas is removed by gravity separation.

TABLE 1—Pressure drop values for different sized gas anchors.

GAS ANCHOR		Pressure Drop In PSI
Size (Inches)	Length (Feet)	
¾	10	21.2
¾	20	42.4
1¼	10	2.3
1¼	20	4.1

The oversized anchor system offers extra benefit by creating a greater agitation in the casing annulus and permitting a larger down-pass area inside the anchor. The oversized anchor is used where maximum separation is needed and the diameter is determined by the casing or hole diameter.

The gas anchor diameter is limited by the size of equipment to which it is attached and by the available inside diameter through which it must be set and operated. In selecting the optimum size gas anchor, pressure drop should not be overlooked. Both the length and diameter affect pressure reductions. In low fluid level wells, increased suction lift can result in partial pump fill and additional liberated gas. Table 1 shows pressure drop values for two different sized anchors. The data[1] were obtained on the basis of pumping 100 centipoise viscosity oil with a 1¾-inch pump at a speed of 20-54 inch SPM.

Table 1 indicates that the short, large diameter anchor would be preferred in wells with relatively large production volumes. Most West Texas area crude voscosities are low and pressure losses are less critical.

The length of the gas anchor should be sufficient to extend the inlet a minimum of 5 to 10 feet below the turbulence existing near the mud anchor perforations. As the length is increased, additional gravity separation time will be available. As a general rule of thumb, the gas anchor diameter would be sized as near as practical to the pump diameter and extend approximately 10 feet below the mud anchor perforations. The mud anchor should be 2½ inch or larger, 20 to 30 feet in length and bull plugged. The perforated nipple should be sized to the tubing string. If cavings or sand cause a well problem, additional mud anchor length would be beneficial.

The most efficient depth for the anchor system will vary with individual wells. The foaming zone near the working fluid level and the turbulent zone where free gas enters the well

bore should be avoided. The system will be more effective if a fluid seal is maintained above the tubing perforations by regulating depth and scheduling pumping time.

PROBLEM EVALUATION

Several methods of testing may be used to determine the probability of penalized production from gas interference. These methods will be discussed in three categories: (1) production tests, (2) operation and equipment studies, and (3) special tools.

Production tests. Various production tests to evaluate pumping well gas problems first involve a review of well history and producing characteristics. Wells that produce less than top allowable; produce considerable gas through the tubing; produce erratically; produce with the casing shut in or choked into a relatively high pressure flow line; produce with a pulling history with small pump repair cost, are prime examples of potential gas problems.

Wells in the above categories may be tested by measuring the gas production separately from the tubing and casing, and evaluating the amount of bottom hole separation actually being accomplished. In instances of either high pressure flow line or shut-in casing, the casing pressure can be vented to the atmosphere at full or chocked flow rates and production tests taken and compared with regular tests.

Frequently, the problem of back pressure can be minimized by lowering separator or heater pressures, removing unnecessary obstructions and cleaning paraffin or scale from the flow lines. These conditions are often responsible for production tests in well head test tanks being greater than tests taken through regular lease equipment. A more accurate evaluation can be accomplished when production test results are compared with operation and equipment studies.

Operation and equipment studies. Equipment studies involve a review of the existing down hole equipment. Pertinent questions should be investigated and answered. Is the pump properly designed to reduce gas problems? Are the valves spaced to give maximum compression? Is the pump capacity greater than the ability of the well to produce? Does rod stretch reduce the actual pump stroke excessively?

High pump capacities can cause gas problems by effecting partial pump filling due to starved suction. Excessive pump speeds have the same effect. Theoretical pump capacity should be compared to actual production, keeping in mind that in deep wells or high fluid level wells, stock tank production may be less than the volume of fluid actually pumped because of shrinkage resulting from liberated solution gas.

A study of operating procedures will point out practices inducive to gas interference. High speed, short stroke length and excessive pumping time are good examples. Every effort should be made to eliminate agitation, choking action or pressure changes after the fluid enters the gas anchor. It is important for field personnel to understand the need for good operating practices to insure that changes in procedures and equipment will not be opposed to proper design.

Special tools. Evaluation of gas interference can best be determined by studies of dynamometer cards. The actual plunger travel, pump efficiency, underfilling of the pump and pump condition can be determined accurately. Gas interference is reflected directly on the dynamometer card by variations in load, and the need for improvements of both an operational and mechanical nature can be determined without the need for lengthy production tests.

If equipment changes are necessary to complete proper analysis, well weighing will point out the need and furnish the necessary data for immediate evaluation after the corrections have been made. Gas interference can distort any method of determining a true picture of whether a pumping system is producing the well capacity. The dynamometer test can show the presence of gas within the pump and set the pattern for correction. Detailed methods covering dynamometer test procedures are contained in a reference publication.[5]

Sonic studies, although important, are not emphasized because it is the pump efficiency, not the annular fluid level, that points out the need for improved gas handling facilities. If dynamometer tests are not available, high fluid level, as indicated by sonic measurement, can indicate the need for increased efficiency or improved pump capacity.

Field tests of gas interference will often indicate problems common to other lease or field wells. Evaluation and corrections for the first well may require some extra expense and trial and error experimentation. However, in most instances the same adjustments will be profitable in other field wells. The need for improvement will have been established and the corrective measures and method of operation will have been determined for incorporation in other wells as they are pulled.

With few exceptions, all wells should be equipped and operated to permit a minimum of gas interference. Occasionally, wells will be equipped in a manner that requires all production to be handled through the tubing. In these cases, low efficiency will be experienced or can be anticipated until economics justify improvements.

When improvements of downhole equipment are impractical, emphasis should be directed toward maintaining the best operating procedures for handling gas. Production increases have been obtained by installing a back pressure valve on the flow line

About the Author

C. J. Merryman received a B.S. degree in petroleum engineering from Louisiana State University in 1950. He then was employed by Sun Oil Company at Delhi, La. He has worked in Sun's Production Department in the West Texas area since 1953. He has written and published a number of papers dealing with oil well pumping and associated problems. He is a member of AIME.

at the well head. Increased back pressure will usually hold a fluid seal on the pump, restrict radical pressure changes and reduce gas breakout in the pump.

Good operating procedures, such as having a pump sized to production, a long, slow stroke, a good compression ratio and a proper time schedule, can not be over-emphasized.

Frequently, the success or failure of a bottom hole gas separation system is completely dependent on operating procedure. This is supported by Example 3 (See Box, Page 76) where a production increase of 94 bopd was obtained by a depth change of one tubing joint.

In the area of operations discussed in this article, the author has not encountered a well with gas problems where efficiency could not be improved with proper equipment and operating procedure, provided facilities permit pumping time scheduling and casing gas venting.

Experience has indicated that a tremendous number of wells are producing below well capacity because of gas interference problems.

Whenever practical, wells should be studied and improvements applied. Flexible rules governing down hole pump and related equipment design can be compiled and applied with close observance of proper operating practices. Application of these principles will assure that gas anchors pay dividends.

ACKNOWLEDGMENT

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First Cambrian oil sparks western Nebraska exploration

Discovery of Lamotte sandstone oil comes as no surprise to Kansas and Nebraska geologists

By Joseph A. Kornfeld, President
Kornfeld International, Tulsa

A RANK WILDCAT discovery of commercial oil production from the Lamotte (Reagan) sandstone in southwest Nebraska's Red Williow County adds major impetus to exploration in the Western Nebraska Basin.

The well, Murfin Drilling Company's Wichita, Barth 1, is 7½ miles northeast of the Ackman (Pennsylvanian) oil field, and 15 miles east of McCook. The nearest Lamotte production is 40 miles southeast of the Barth 1, in the Norton field (Arbuckle).

The Lamotte sandstone of the Cambrian system, at the base of the Paleozoic immediately above the basement rocks, marks the geologically oldest crude oil production in Nebraska.

Discovery of Lamotte oil off the southwest flank of the Cambridge Arch did not come as a surprise to Kansas and Nebraska geologists. They have long predicted that the truncated, overlapped rocks of pre-Pennsylvanian age would be a valid objective for important petroleum exploration.

Lamotte lithology. The Lamotte sandstone in the Barth 1 consists of clusters of white, fine to coarse-grained calcareous sandstone. Its age is basal Upper Cambrian and the rocks lie at an angular unconformity and disconformity over the eroded basement complex of igneous and metamorphic rocks (Figure 2).

Drillstem evaluation. The Lamotte was encountered in Barth 1 at 3,418 feet—29 feet higher than a dry hole four miles southwest and 86 feet higher than Murfin Drilling Company's Haag 1, 7 miles to the southeast.

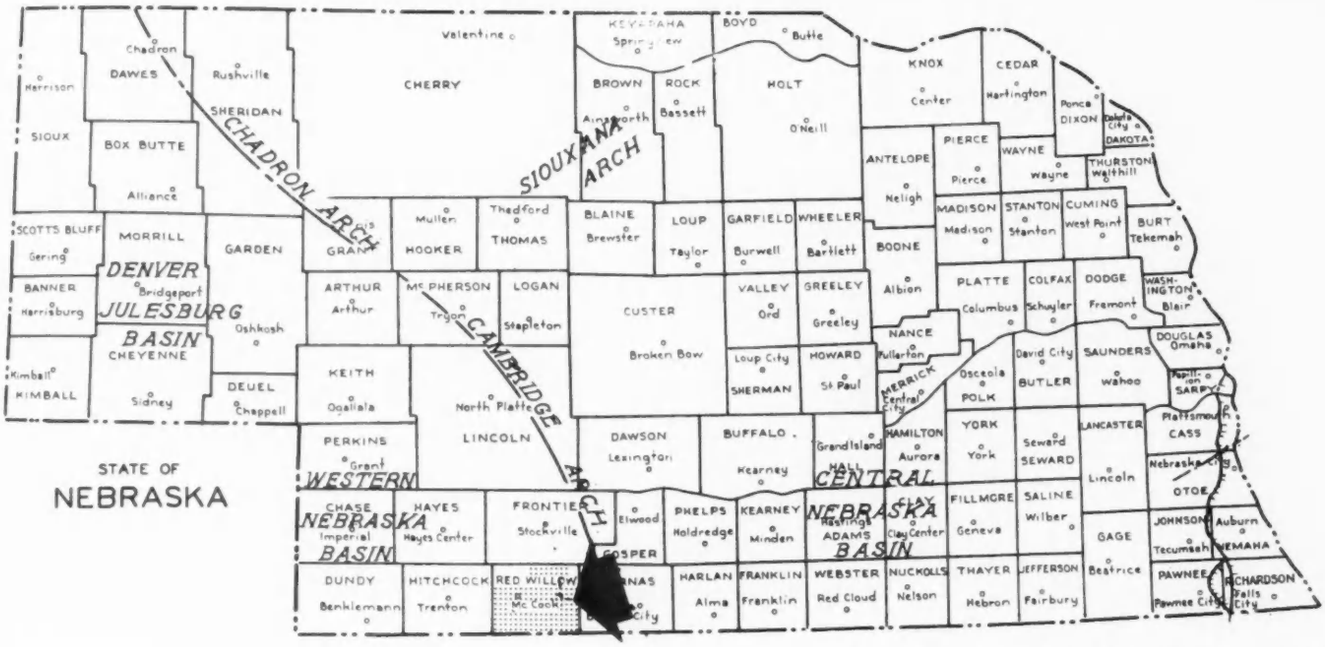
Calculations of the Lamotte interval from 3,418-3,426 feet gave 26 percent porosity with 30 to 35 percent water saturation. The following drillstem tests were conducted on the reservoir:

Test No. 2
Test Interval—3,395-3,420
Test Data Summary—Tool open for two hours. Recovery: 5 feet of clean oil and 65 feet of heavily oil-cut mud; IP 0 psig; FFP 0 psig; SIBHP 245 psig in 20 minutes.

Test No. 3
Test Interval—3,395-3,425
Test Data Summary—Tool open for one hour. Recovery: 660 feet gas, 120 feet mud-cut oil, and 305 feet oil. IFP 115 psig; FFP 260 psig; SIBHP 880 psig in 20 minutes.

Completion results. Barth 1 was drilled to 3,490 feet in pre-Cambrian basement rocks encountered at 3,453 feet. The 5½-inch oil string was set at 3,488 feet and casing perforated from 3,418-3,422 feet for completion.

Crews swabbed 3 barrels of crude per hour, then perforated an addi-



(Base map courtesy Norvell D. Snyder, manager, Kansas Blue Print Co., Wichita, Kansas)

FIGURE 1—First Cambrian oil production for Nebraska is indicated by black arrow pointing to Murfin Drilling Co. Barth 1, C SE SW/4 Sec. 25-3N-27W, 15 miles east of McCook in Red Willow County, Nebraska, which pumped 115 barrels of oil per day through casing perforations from 3,418-3,425 feet, in the Lamotte sandstone.

tional 3 feet from 3,422-3,425 feet and swabbed 7½ barrels an hour after a 500-gallon acid wash.

Granite wash pay zone. Another commercial oil reservoir was discovered in the Barth 1 well from the Granite Wash zone immediately below the Lamotte pay, without an apparent separating lithologic break. Thus, it may be assumed that both the Lamotte sandstone and the Granite Wash are a single reservoir.

Formation evaluation. Following is an analysis of sample descriptions and electric log intrepretations of the Granite Wash pay zone:

Interval: 3,425-3,434 feet. **Thickness:** 8 feet. **Lithology:** Sandstone, arkosic and weathered, pink feldspar. Trace stain. Free oil. Faint odor. **Porosity:** 19-24 percent. **Water Saturation:** 40 percent.

Interval: 3,425-3,434 feet. **Thickness:** 2 feet. **Lithology:** Sandstone, arkosic and weathered, pink feldspar. Slight traces of stain. Trace of free oil. No odor. **Porosity:** 14-17 percent. **Water saturation:** 60-70 percent.

Brisk Pennsylvanian activity. Meanwhile, development of a series of Pennsylvanian oil fields continues in Red Willow and Hitchcock counties in the current drilling trend that has spilled over into southwestern Nebraska from northwestern Kansas fields (Rawlins and Decatur counties).

Silver Creek field. Four miles south of the Barth field, Burch Drilling Company's Wichita, Nokes 1 failed to find production in the Lamotte sandstone in drilling to 3,595 feet. However, it plugged back, and after setting pipe through the Lansing-Kansas City lime series, perforated that group from 3,248-3,302 feet, and pumped two barrels of oil per hour on initial pumping test.

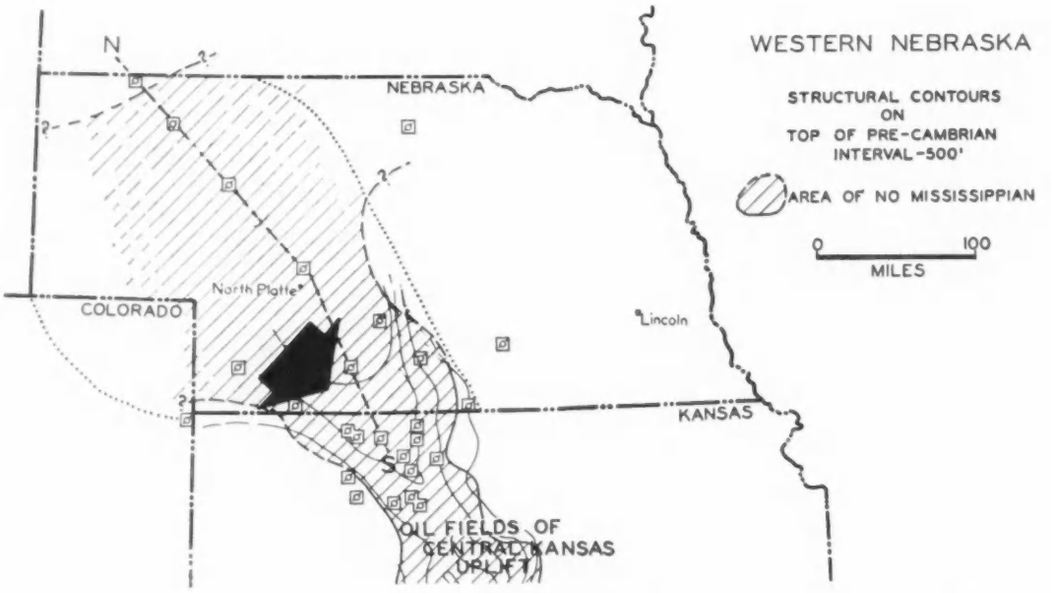
Ackman field. The largest developed Pennsylvanian field in Red Willow county is the Ackman field in Township 2 North, Range 28 West, about 10 miles southeast of McCook. There currently are 14 producing oil wells completed from three pay zones in the Pennsylvanian.

Wichita Geologist Predicts Important Oil Sub-province

V. Jean Taylor, Wichita, consulting petroleum geologist, in an interview prepared for WORLD OIL, predicts a bright future in exploration for Pennsylvanian structures lying in the Western Kansas Basin west of Graham county.

"There is no question in my mind," he said, "when we get sufficient density of well control west of Graham county to enable the subsurface geologist to do more than contour regionally, that favorable structures capable of accumulating significant petroleum reserves will be found."

Taylor speaks from field experience covering approximately 350 wells on the rig floor in western Kansas over the past two decades. After graduation from the University of Iowa, he was employed as a subsurface geologist for ten years with Shell Oil Company. During the past ten years, he has been engaged as a well-site and subsurface geologist in western Kansas and has done considerable field work throughout Graham, Sheridan, Decatur, Norton, Rawlins, and Cheyenne counties.



(Courtesy Tulsa Geological Society and AAPG)

FIGURE 2—Present attitude of the top of the eroded pre-Cambrian surface comprised of igneous and metamorphic rocks over the Cambridge and Chadron arches of western Nebraska is shown in this subsurface structural and paleogeological map. Arrow points to position of discovery well of the first Cambrian oil for Nebraska, east of McCook in Red Willow County, Nebraska.

Development as of July 10, 1960, indicated a proved developed area covering as much as 720 acres for the Lansing-Kansas City "B" and "C" zones and 200 acres for the Oread oil reservoir. Combined proved developed stock-tank oil in place for the aggregate three zones totaled 4,556,800 barrels.

Since the field is only nine months old, it is too early to determine the character of the reservoir drive from field history.

The field was discovered last November by a Frontier Refining Company well completed through perforations from zones "B" and "C" in the Lansing-Kansas City group from 3,273-3,278 feet and from 3,307-3,310 feet. Initial production was 122 barrels of oil per day plus 6.5 percent of salt water on the pump.

Geology of the area. The Western Nebraska Province covers approximately 45,000 square miles, or the western half of the state. The sediments have a total volume of 35,000 cubic miles, and these range in age from Upper Cambrian through Quaternary sands and gravels.

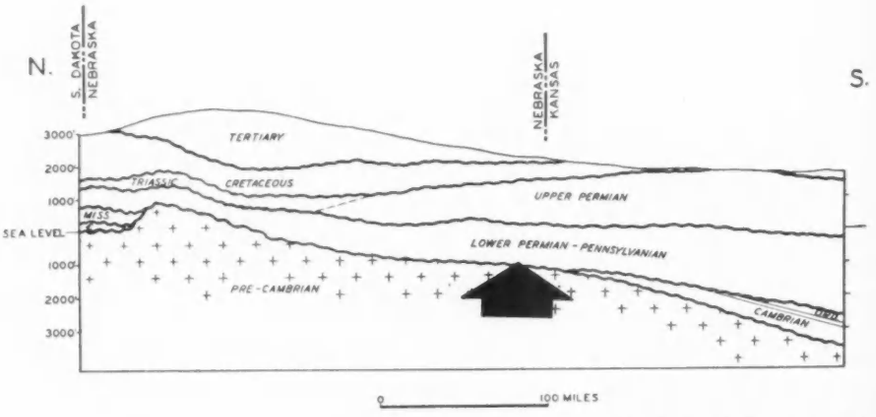
This province has been a positive element throughout most of geological time. It offers a major potential for stratigraphic and structural traps due to many uncomformities and hiatuses in sedimentation in the geological column.

Over a considerable portion of the province, formations ranging from Ordovician through Mississippian are absent either by non-deposition or truncation, or a combination of these two conditions.

One of the principal periods of uplift occurred in early Pennsylvanian (post-Morrow, pre-Des Moines) time, as in many other parts of the Mid-Continent region. For example, in the new Barth (Lamotte) oil field, the Lansing-Kansas City group is draped over the Cambrian rocks (Figure 3).

Most of the post-Paleozoic movements in this region consisted of regional westward tilting in pre-Cretaceous and post-Tertiary time. This accounts for the westward thickening of the Mesozoic and Tertiary formations into the Denver-Julesburg basin.

Exploration of this province has been handicapped by the presence at the surface of thick deposits of un-



(Courtesy Tulsa Geological Society and AAPG)

FIGURE 3—Regional cross-section of the Chadron and Cambridge arches of the western Nebraska province is shown above prepared along a north-northwest N-NW to S-SE line of section. Arrow points to the approximate position of the Lamotte (Reagan) sandstone oil discovery, the first for Nebraska, described in this article, and illustrates the draping effect of the Pennsylvanian carbonates over the Cambridge arch.

consolidated sands and gravels of Tertiary and Quaternary age which obscure the character of the sub-surface structure.

EXPLORATION OBJECTIVES

Pre-Cambrian basement complex. The crest of the Cambridge and Chadron arches offer objectives in the eroded, fractured basement complex of metamorphic and igneous rocks.

This type of production is known nearby over the Central Kansas Uplift on the crest of local eroded knobs occupying the highest structural levels of the uplift in Rice and Russell counties.

Granite Wash. The occurrence of commercial quantities of oil from the granite wash is indicated on the Cambridge Arch for the first time in the new Barth pool, although it is not being produced at present. This occurrence is an unconformity accumulation encountered in talus slopes near these buried pre-Cambrian promontories which are well known over the Central Kansas Uplift.

Lamotte (Reagan) sandstone. The exploration history of Lamotte (Reagan) oil production from the Upper Cambrain in the Norton and Ray pools over the Central Kansas

Independent Drilling Contractors Attracted to New Exploration Flanking Cambridge Arch

THE DISCOVERY operator of the new Barth (Lamotte) Oil field in Red Willow County, Nebraska, is confident that economics justify further entrance of many independent drilling contractors into the new shallow (3,700-foot) Cambrian-Granite Wash play extending northwestward from the Central Kansas Uplift.

In an interview with WORLD OIL, Fred Murfin, president of Murfin Drilling Company, Wichita contractor, who found Nebraska's geologically deepest oil reservoir, said that he was confident that "there will be work" although he observed that "we don't know what the reserves will be."

But he noted that the McCook area "was as good as any place to drill for oil in the Mid-Continent region," adding that "I'm sure that we will find more accumulations of this type."

Economics. Drilling costs for a 3,700-foot test are $14,000 for a dry hole, and $35,000 for a completed well to the tanks. About 10 days are required from rigging-up to setting of oil string and an additional three days for cable-tool completion operations. A 13-inch surface hole is cut to about 100 feet to set the 8⅝-inch casing; and the hole reduced to 7⅞-in., in which the 5-inch oil string is set at 3,700 feet.

Barth 1 tested 32 degrees API on the first tank run, which brings $2.77 per barrel (based on the Colorado posted price by The Pure Oil Co. of $2.93 per barrel for 40 degree API crude). A trucking charge of 51 cents per barrel leaves a net price of $2.26 per barrel.

Rock Island Oil & Refining Company, Wichita, the purchaser, is temporarily taking 50 barrels of oil per day from Barth 1 and delivering it to the Colby, Kans., station of the Arapahoe Pipe Line Company.

Exploration method. Subsurface geology with special attention to paleogeology study of old strand lines and *subcrop of pre-Pennsylvanian rocks against the southwest flank of the Cambridge arch* was ascribed by Murfin as the principal exploration method.

The Barth discovery came after Murfin drilled two dry holes in eastern Red Rillow county, Murfin said, explaining that "we looked for it." These were Haag 1, 7 miles southeast of the discovery well; and Ingram 1, 11 miles southeast of the discovery well.

TABLE 1. Summary of Reservoir Characteristics
Ackman (Pennsylvanian) Oil Field, Red Willow County, Nebraska
(Effective Date: July 10, 1960)

Group	Zone	Average Values of Reservoir Characteristics				STO In Place [c] Bbl./Af	Proved Developed Reservoir Volume			Proved Developed Oil in Place ST Bbls.
		Porosity Pct.	Permeability Md.	Oil Saturation Pct.	Water Saturation Pct.		Acres	Net Pay	Ac.-Ft.	
Lansing K.C.	Oread	18[a]	180	17	60	507	200	4	800	406,400
	"B"	9[b]	50	26	50	317	400	5	2,000	634,000
	"C"	14[b]	28	18	45	444	720	11	7,920	3,516,480
Totals									10,720	4,556,880

Legend:
Porosity Types
[a] Interstitial
[b] Fractured and vugular
Oil in Place Calculations
[c] Using formation-volume factor of 1.1 bbl. reservoir oil/bbl. residual oil; average produced oil gravities Oread: 29 deg. A.P.I. Lansing-Kansas City group: Zone B: 31 deg. A.P.I.; Zone C. 31 deg. A.P.I.

SYSTEM	SERIES	GROUP OR FORMATION	DESCRIPTION AND APPROXIMATE MAXIMUM THICKNESS
Quaternary	Pleistocene		Stream deposits of clay, silt, sand, gravel, glacial, till; eolian deposits of sand and silt, volcanic ash 250'
Tertiary	Pliocene	Ogallala formation	Gravel, sand, silt, clay, and caliche, locally cemented to form mortar beds 350'
Cretaceous	Gulfian	Pierre shale	Shale, black to gray, locally chalky concretions, selenite, bentonite 1400'
		Niobrara formation	Calcareous shale and chalk, gray and tan 750'
		Carlile formation	Shale, black to dark gray; septerians in upper part, locally fine sandstone at top, bentonite and chalky in lower part 300'
		Greenhorn limestone	Chalky limestone and calcareous shale, gray to tan 132'
		Graneros formation	Shale, blue-black non calcareous 65'
		Dakota formation	Clay, shale, siltstone, sandstone 300'
	Comanchean	Kiowa formation	Shale, gray and black, fissile, some sandstone and limestone, selenite crystals 150'
		Cheyenne formation	Sandstone, shale, conglomerate at base locally; varicolored 300'
Jurassic		Morrison formation	Shale, chiefly green with pink chert, subsurface 300'
Triassic		Dockum (?) group	Sandstone and siltstone, red, white, buff 100±
Permian	Guadalupian	Taloga formation	Red beds of silty and sandy shale and sandstone 45'
		Day Creek formation	Dolomite, fine grained to dense 2'
		White horse sandstone	Red beds of sandstone, siltstone, and shale, some dolomite 270'
	Leonardian	Nippewalla group	Red beds and sandstone, siltstone, and shale, prominent gypsum beds, some dolomite 930'
		Sumner group	Chiefly shale, mostly gray at outcrops, largely red and with salt and anhydrite in subsurface 1000±
	Wolfcampian	Chase group	Shales, bright-colored, and limestones, partly cherty 350'
		Council Grove group	Shales, gray and varicolored, limestones, light colored 300'
		Admire group	Largely clastic, thin, persistent limestones. Local unconformity at base 150'
Pennsylvanian	Virgilian	Wabaunsee group	Largely clastic, considerable sandstone, thin persistent limestones, several coal beds 500'
		Shawnee group	Limestone, shales, and sandstones, some coal 350'
		Douglas group	Chiefly clastic, shales and sandstones; local disconformity in middle part 250'
	Missourian	Pedee group	Chiefly shale, limestone at top 140'
		Lansing group	Chiefly limestone, part shale 150'
		Kansas City group	Limestone, shale, sandstone, some coal 400'
		Pleasanton group	Chiefly shale, some sandstone and limestone 150'
	Desmoinesian	Marmaton group	Shale and persistent limestone, relatively thick sandstone lenses in eastern Kansas 350'
		Cherokee: Cabaniss gr, Krebs group	Mostly clastic, dark and light gray shales, sandstone lenses, several coal beds, little limestone 750'
	Atokan	undifferentiated	Chiefly limestones and shaly ls., identified only in subsurface in southwestern Kansas 500'
	Morrowan	undifferentiated	Shales, limestones and sandstones. Known only in southwestern Kansas 350'

SYSTEM	SERIES	GROUP OR FORMATION	DESCRIPTION AND APPROXIMATE MAXIMUM THICKNESS
Mississippian	Chesteran		Shales, soft gray; fossiliferous; limestones light colored. Reported only in southwestern Kansas 400'
	Meramecian	Ste. Genevieve limestone	Limestone, light colored, oolitic, locally silty. In northeast Kans. 30' In southwestern Kans. 215'
		St. Louis limestone	Limestone, lithographic In northeast Kansas 50' In southwest Kansas 200'
		Spergen limestone	Limestone and dolomite, sparsely cherty In northcentral Kansas 50' In southwestern Kansas 100'
		Warsaw limestone	Limestone and dolomite, cherty 90'
		Cowley formation	Limestone and dolomite, dark, silty, cherty, glauconitic at base 464'
	Osagian	Keokuk and Burlington fms.	Limestones and dolomites, white and gray, cherty 295'
		Reeds Springs fm.	Limestones and dolomites, cherty 155'
		St. Joe formation	Limestones and calcareous shales 90'
		Gilmore City fm.	Limestones, white, soft, part oolitic 120'
		Sedalia (North view in southeastern Kans.)	Dolomite, buff, sparsely cherty; mostly shale in southeastern Kansas 30'
		Compton formation (Chouteau)	Dolomite, buff, sparsely cherty 45'
Devonian or Mississ.		Boice shale	Shale, dark or light greenish, gray, silty, sporebearing and basal red shale; ferruginous oolites 110'
		Chattanooga shale	Shale, black in southern Kansas, gray in northern Kans. Misener ss. at base
Devonian	"Hunton"	Cooper ls.	Limestone and dolomite 350'
Silurian		Chimneyhill limestone	Limestone and dolomite, cherty, in part oolitic 200'
Ordovician	Upper	Sylvan (Maquoketa shale)	Shale, silty, greenish, gray, dolomitic, locally cherty 155'
	Middle	Viola (Kimmswick ls.)	"
		Simpson group	Including Platteville limestone (in North Kansas basin); St. Peter sandstone and lower bed, sandstone, shale, limestone and dolomite 290'
	Lower	Arbuckle: Cotter dolomite, Jefferson City dolomite	Dolomites and dolomitic limestone 405'
		Roubidoux	Dolomites, sandy in part 200'
		Gasconade dolomite Van Buren fm.	Dolomite with Gunter sandstone at base 200'
		Eminence dolomite	Dolomites, buff to white, cherty 150'
Cambrian	Upper	Bonneterre dolomite	Dolomites and dolomitic limestones, interbedded shale, green to bluish brown glauconitic 150'
		Lamotte (Reagan) ss.	Sandstone, yellow, white, locally arkosic 130'
Pre-Cambrian			Basement complex, igneous and metamorphic rocks

(After J. M. Jewett, Kansas Geological Survey, 1955).

FIGURE 4—The geologic position of the new oil producing formation for Nebraska —the Lamotte (Reagan) sandstone—of upper Cambrian age recently discovered in Red Willow county, southwestern Nebraska, is indicated by solid arrow. The hollow arrow points to the Lansing-Kansas City groups of the Missourian series of Pennsylvanian age productive in other fields in Red Willow county on the southwest flank of the Cambridge Arch in the Western Nebraska basin.

Uplift will be a guide to similar exploration over the Cambridge arch, recently highlighted by the new Barth pool discovery from this formation objective.

The current exploration trends in the Western Nebraska Basin follows a northwestward direction from Red Willow County into Frontier, Hayes and Lincoln counties.

Arbuckle formation. This formation offers a valid objective on the feather-edge pinchout on local structures on the southwestern flank of the Cambridge arch in the Western Nebraska Basin.

Detailed sample studies, electric and neutron log cross-sections and regional paleogeologic maps should be utilized in an exploration program for this important objective.

Mississippian. The subcrop of the Mississippian in Hitchcock and Dundy counties, Nebraska as well as in Rawlins and Cheyenne counties, Kansas, may offer another objective in the Mississippian rocks in the region.

Zonation of the Mississippian from sample descriptions and sample logs offers a valid approach similar to that which may be employed in search for subcrops of the Arbuckle formation of Ordovician age.

Lansing-Kansas City group. Pennsylvanian carbonates become thinner and their percentage in the total rock column progressively less along the north-northwestward axis of the Western Kansas Basin from Graham County, Kansas.

The shales, which thicken percentage-wise, change lithologically from grey and grey-brown to red and red-maroon colors (typical Permian types) throughout the section. Black shale streaks occur only sparsely. However, persistent carbonaceous black shale layers, such as the Heebner shale, found about 38 feet above the Lansing limestone in southwestern Graham County, form significant datum planes and correlation markers.

Definite and continuous shale layers separate individual reservoir rock layers of the Lansing-Kansas City group in which oil has been found. However, this condition is in direct contrast to those areas lying over the Central Kansas Uplift where a thinning or even a complete disappearance of shale may have allowed for communication between reservoir rocks.

These intervening shale intervals of the Lansing-Kansas City group stud-

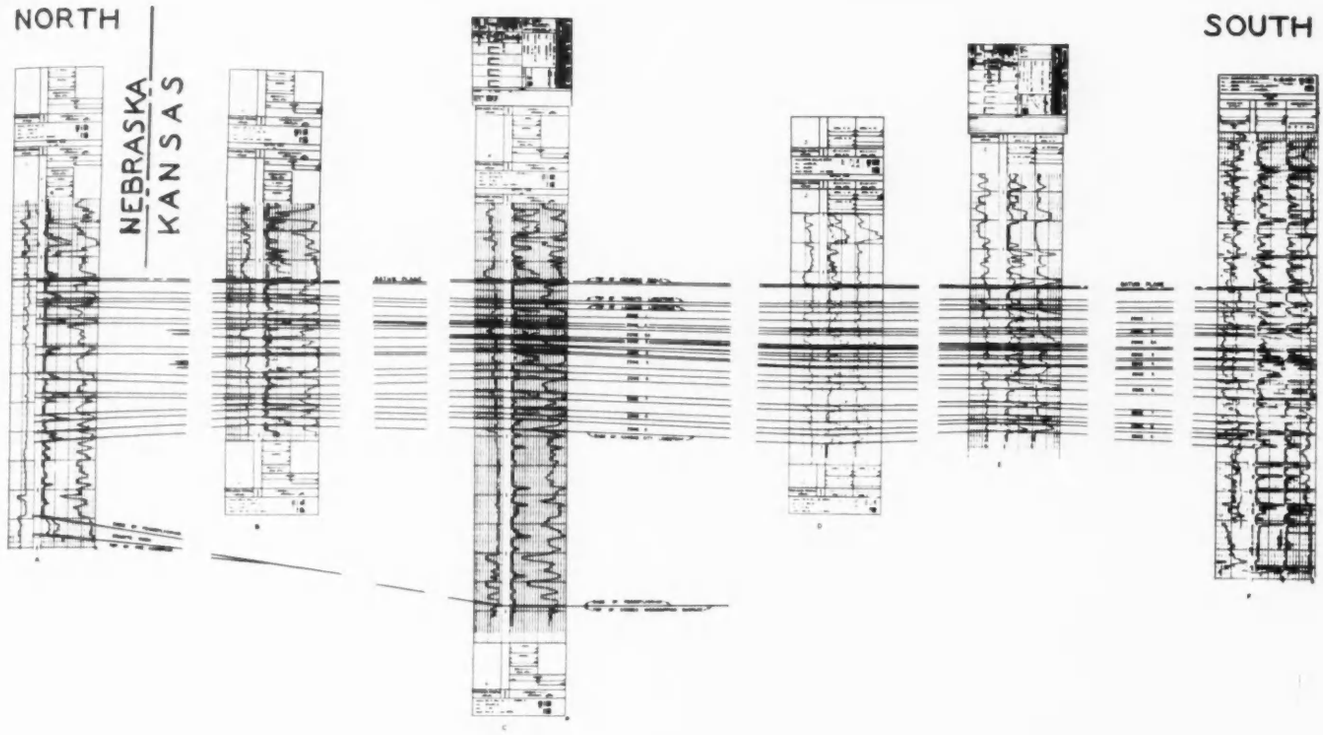


FIGURE 5—Geological controlling factor in oil accumulation in the Lansing-Kansas City group of carbonates of Pennsylvanian age in the Western Nebraska Basin is facies changes from carbonates on the south to replacement by Permian-type shales on the northwest. This is strikingly illustrated by this north-south electric log geologic cross-section extending from Red Willow Co., Nebraska south and southeastward across Sheridan, Decatur, Rawlins and Graham counties, Kansas. Wells used in this cross-section are: A—Murfin Drlg. Co. Ingram 1, C SE NE/4 Sec. 5-1N-26W, Red Willow County; B—Empire Drlg. Co. E. J. Curley 1, NE NE SW/4 Sec. 30-7S-29W, Sheridan Co.,; C.—Empire-Appleman, Marcuson 1, C NW NW/4 Sec. 4-5S-29W, Decatur Co.; D—Empire Latimer 1, NE NE NE/4 Sec. 12-5S-31W, Rawlins Co.; E— Empire Dutton 1, SW SW SW/4 Sec. 26-6S-27W, Sheridan Co.; and F—Empire-N.C.R.A. Dinkle "B-6, Sec. 10-10S-25W, Elrick pool, Graham County, Kansas.

ied from wells drilled in western Graham and Sheridan counties, wash out very badly in the course of drilling operations. Incompetence of the shale body and resulting out-of-gauge hole, is the direct cause of many poor cement jobs and channeling during acid treatment stimulation.

In general, total porosity development appears to have remained fairly constant from the Graham-Sheridan county area north-northwestward into the Western Nebraska Basin. Although the carbonates exhibit less total footage, yet the total thickness of effective porosity remains fairly constant.

Oread limestone. The shallowest objective produced to date in the new province is the Oread limestone which is one of the three producing formations in the new Ackman field of Red Willow County, Nebraska.

The high porosity and permeability, and satisfactory oil saturation are encouraging as an auxiliary objective despite the relatively thin pay zone encountered in Ackman field wells to date.

WELL LOGGING PROGRAM

Basic conditions. The principal producing reservoir objectives lying on the southwest flank of the Cambridge Arch are porous carbonates lying in the Lansing-Kansas City limestone series of Pennsylvanian age, basal Pennsylvanian conglomerates, and detrital sandstones lying at unconformities between the Pennsylvanian rocks and the eroded pre-Cambrian promontories.

Porosity development in the Pennsylvanian carbonates is comprised of a series of thin pay zones. These layers range from 2 to 8 feet per zone. Formation waters are relatively saline and the drilling muds used are fresh water base.

ROTARY RIG REQUIREMENTS

Rotary drilling requirements for exploration and development work in the Western Nebraska Basin should be arranged into two depth classifications: The first to 5,500 feet; the second to 7,500 feet.

Most 5,500-foot drilling rigs in western Kansas are equipped with a 7¼ x 12-inch or 7¼ x 14-inch pump which performs satisfactorily to 5,000-foot depths.

When drilling deeper than 5,000 feet, a larger pump (7½ x 15-inch) would prove to be more profitable and practical.

ACKNOWLEDGMENT

The following aided in making available technical material used in this report: Fred Murfin, Murfin Drilling Company; Dan J. Kornfeld, Empire Drilling Company; V. Jean Taylor, consulting petroleum geologist, W. D. Ford, Schlumberger Well Surveying Corporation, J. G. Carter, The National Supply Company; Norvell D. Snyder, Kansas Blue Print Company, all of Wichita, Kan. The electric log geologic cross-section was prepared with the assistance of Lloyd Goodson, manager, Allied Reproductions, Tulsa, with electric logs furnished by Empire Drilling Company and Murfin Drilling Company.

New field is indicated for Chile on Tierra del Fuego

On Tierra del Fuego, about 30 miles south of Gaviota field, Empresa Nacional del Petroleo (ENAP) has an apparent oil discovery at Rio Chico. If successfully completed, this test will be the southernmost discovery on the Chilean side of the island. About 262 feet of Spring Hill sand, broken with shale stringers, was found with oil saturation between 9,662 and 9,924 feet. The discovery well has been plagued with completion troubles.

On the mainland, north and slightly west of Delgado field, Molino 1 has been completed as an oil well, making a large proportion of salt water. Molino 2 was drilling below 3,200 feet late in April.

Subsurface data indicate the possibility of a large closure below the Magellan Strait encompassing both Delgado Este and Faro Este fields. Some offshore seismic work was being done to check this possibility. About six wells had been completed below the Strait in Delgado Este, drilled directionally from shore, as of late April 1960.

A 38-mile, 8-inch crude oil pipe line from Delgado Este field to San Gregorio terminal was being completed late in April. A previously-proposed pipe line project to traverse the Magellan Strait was dropped in favor of separate terminal facilities on the mainland.

Farther north, surface geological exploration is being started in Aysén, south of Golfo de Penas.

In Tarapacá in the northern desert, seismic exploration by ENAP is progressing well, and some wildcatting is expected late in 1960 or early in 1961.

ENAP was utilizing four drilling rigs early in 1960, having junked one.

Argentina: Pan American International Oil Company had 14 rigs running as of May 10 in the Comodoro Rivadavia area. Well 165 was being drilled at that time. Crude oil production was running at about 23,000 barrels daily; however, some wells remained unconnected.

Chile: The first wildcat to be drilled in Tarapacá Province in the northern desert may be located near Pica. Drilling is expected to commence in the northern desert by late 1960 or early 1961.

France: Esso REP's Cazaux oil field, located about 35 miles northwest of Parentis in the Aquitaine Basin, appears to be a commercial pool. A total of 1,682 barrels of oil daily was flowing from 5 wells in April, 1960. Aptian and Albian sandstones are productive.

Cazaux 4 was perforated from 8,727 to 8,783 feet and also from 8,612 to 8,631 feet, and was completed late in April, initially flowing 787 barrels daily. Total depth was 9,514 feet.

Cazaux 6 was drilled to about 9,000 feet in tight Neocomian sandstone, equivalent to the main pay zone at Parentis. Oil was found in Aptian and Albian sands and gravels. About 50 feet of oil-saturated pays were found.

Cazaux 7 was drilling below 7,316 feet on May 1.

For a complete roundup of world trends and activity, read World Oil's . . .

INTERNATIONAL OUTLOOK SECTION

. . . your second issue of World Oil this month . . . to be published August 15

Iran: SIRIP's first wildcat in the Persian Gulf appears to have found several good shows of oil. Reliable reports indicate drill stem tests yielding 20 stands of oil from a Tertiary zone at about 7,300 feet and about 25 stands of oil from a Cretaceous zone at about 9,200 feet . . .

Neutral Zone: Arabian Oil Company, Ltd expects to complete 7 or 8 wells during 1960, with two offshore rigs working. A base at Ras Al Khafji onshore is under construction. A submarin pipe line from offshore wells to shore is expected to be completed by the end of 1961. Temporary offshore loading facilities are to be constructed offshore. A tentative production target of 175,000 barrels of crude daily by 1965 has been mentioned.

A new oil discovery by Arabian Oil Company, Ltd offshore from the Neutral Zone is expected to find a ready market in Japan. Reasons: it is sweet (at least compared to many other Middle East crudes); and it is rather high in aromatics, hence more adaptable to Japan's highly-developed petrochemical industry.

Pakistan: Stanvac has discovered a sizable gas field in West Pakistan, at Mari about 65 miles southeast of Sui field. Three wells have been completed in the Mari limestone, a Tertiary formation lying slightly higher in the section than the Ranikot limestone. Productive depth at Mari is about 2,700 feet. Mari gas is about 30 per non-combustible but still runs about 750 Btu. Mari may be a major gas field about half the size of Sui. Marketing Mari gas will be a serious problem in the foreseeable future.

Qatar: Shell Company of Qatar, Ltd's mobil offshore drilling outfit Seashell was drilling below 8,000 feet in April 1960 at a location 55 miles off the east coast of Qatar. Coordinates are 25°30′ north latitude, 52°24′ east longitude. Oil shows were unofficially reported below 8,500 feet.

Saudi Arabia: Early in May, Arabian American Oil Company was drilling Manifa 7, Abu Hadriyah 5, and additional development continued at 'Ain Dar. Khurais 14 had been completed, and no further drilling was being done there. A refraction survey was being done in the Rub 'al-Khali.

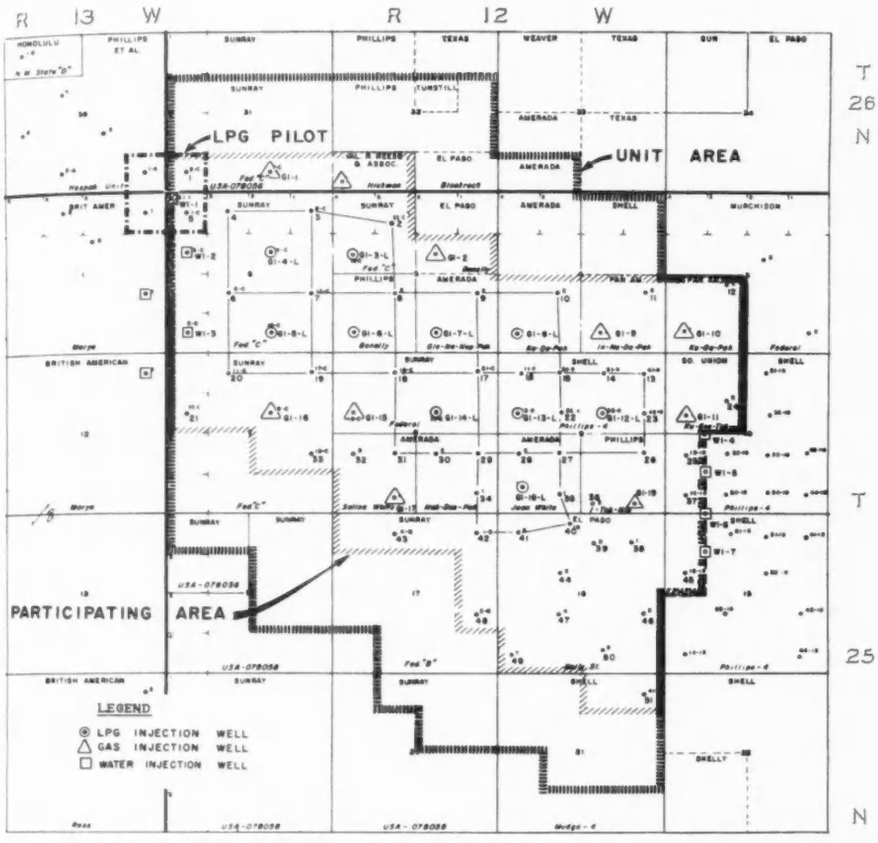


FIGURE 1—Sunray's successful LPG pilot flood is located in the Bisti Lower Gallup pool, San Juan County, New Mexico. Details of the Central Bisti Unit, formed on the basis of pilot performance, are shown here.

In New Mexico's Bisti field . . .

Sunray's LPG pilot test is paying off

By T. W. Brinkley, Chief Reservoir Engineer,
Sunray Mid-Continent Oil Co., Tulsa

SUNRAY MID-CONTINENT OIL COMPANY's successful LPG pilot test in the Bisti pool, San Juan Basin, New Mexico, indicates an additional six million barrels of oil may be recovered from the Central Bisti Unit through application of miscible phase flooding. The project provides for injection of 935,000 barrels of LPG in advance of natural gas in order to sweep the reservoir. The unit comprises approximately 7,000 acres. Sunray is the operator and others participating in the unit include Phillips Petroleum Company, Amerada Petroleum Company, El Paso Natural Gas Company, Pan-American Petroleum Corporation, Southern Union Oil Company and Shell Oil Company.

The Bisti Lower Gallup oil pool is located approximately 20 miles south of Farmington, San Juan County, New Mexico. The pool is approximately 32 miles long and varies from ½ to 3 miles in width; the trend is northwest-southeast.

The LPG pilot 160-acre area, located on the common boundary of the Western and Central Bisti units is shown in Figure 1.

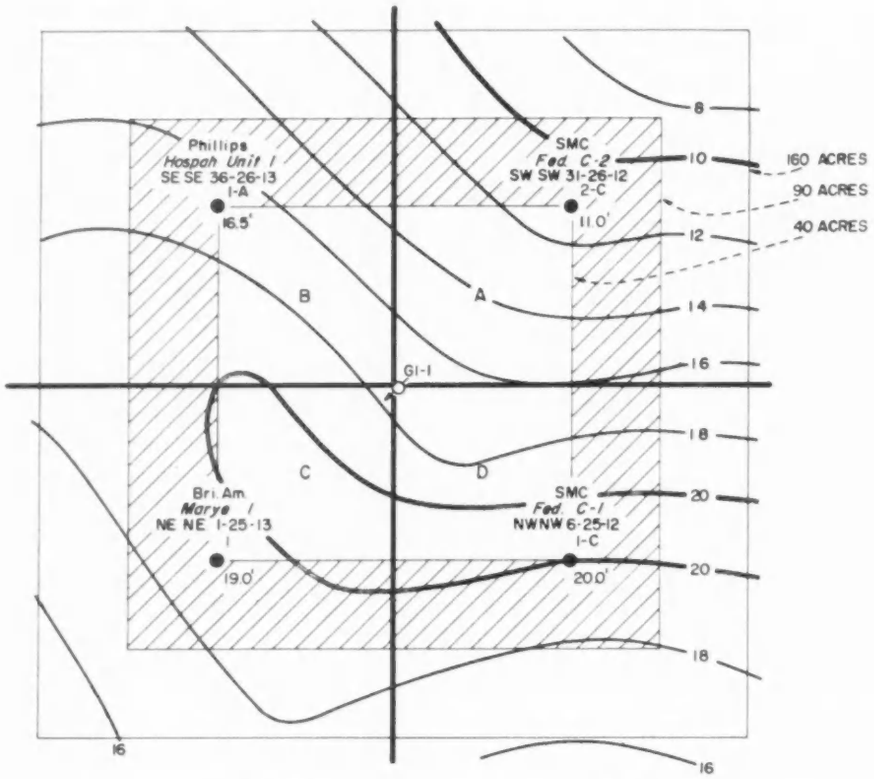
This article discusses the 160-acre LPG pilot area and is intended to present information on geology, reservoir characteristics, reservoir fluids and production history during the two-year life of the test. Interpretations are confined to basic fundamentals—isopach maps, volumetric oil in place, reservoir pressures, etc., and no attempt is made to extrapolate interpretations beyond this scope. Comments are made, however, in directing attention to items that affect interpretation beyond the scope of this article.

Geology. At Bisti, the Lower Gallup sandstone of the Mesa Verde group is of Upper Cretaceous age. Lower Gallup sands are encountered at a depth of approximately 4,900 feet and have an average gross thickness of 130 feet. The gross thickness contains alternating layers of sandstone, sandy shale and shale, with only approximately 20 percent of the total section possessing permeability greater than one millidarcy. The most permeable section is identified as the upper bench located near the top of the Lower Gallup section.

The upper bench is the principal oil producing interval and is described as light grey, medium grained, clean, well-sorted sandstone with variable permeability. The lower sands (below the upper bench) are inferior in both porosity and permeability and are silty, fine grained sandstones with irregular dark grey micaceous shale inclusions and partings. The best development in the sands—porosity, permeability and thickness—parallels the major axis of the long, narrow sand bar with interpreted sand pinchout along the edges. This development thus forms a stratigraphic trap.

Reservoir characteristics. A total of 35 wells, located west of the Carson Unit, have cored portions of the Lower Gallup sand. Twenty of these wells cored sufficient section to permit histograms, which revealed 97.35 percent of the total permeability capacity was in reservoir rocks possessing greater than 1.1 millidarcys. Calculation of hydrocarbon-porosity from all core samples in the 35 wells revealed an average of 12.16 percent for the upper bench and 7.83 percent for the second bench.

Results of core analyses from 29 feet of cores in the Sunray Mid-Con-



GRID	40 ACRES ENCLOSED FIVE SPOT ACRE FEET	OIL IN PLACE	90 ACRES OPEN FIVE SPOT ACRE FEET	OIL IN PLACE
A	168.50	121,295	309.03	222,458
B	173.94	131,798	374.97	283,967
C	199.96	166,215	428.13	355,883
D	181.76	141,561	407.92	317,709
	724.16	560,869	1520.05	1,180,017

FIGURE 2—The grid arrangement on this microlog isopach map of the pilot area indicates the initial stock tank oil in place in each quadrant. Federal C-2 encountered only 11 feet of sand of inferior quality.

tinent Federal C-1 and the LPG pilot injection well in NW corner of Section 6-25N-12W, revealed a hydrocarbon porosity of 14.7 percent. These latter two wells illustrate improvement in hydrocarbon porosity for "fairway" wells as compared to an average value reflected from the random locations of the 35 wells cored.

Net pay thicknesses for the Lower Gallup sands were determined by positive microlog separation and SP area/static SP method. Both methods were desirable in Bisti since a positive microlog separation was not a requisite for production and the SP area method was recognized as probably optimistic.

The SP area method incorporated an adjustment based on core data correlation. The microlog isopach of the upper bench in the pilot area is illustrated in Figure 2. The Figure reflects a grid arrangement with initial stock tank oil in place for each quadrant. The two south wells (British American Marye 1 and Sunray Mid-Continent Federal C-1) are in the better sand development area of the reservoir along the major axis of the pool. The northeast well (Sunray Mid-Continent Federal C-2) is located near the edge of the sand bar and encountered 11.0 feet of inferior quality sand. The northwest well, Phillips Hospah 1-A, represents more nearly average rock characteristics. These qualitative characteristics are reflected in individual well performances during the LPG flood test, as will be illustrated later.

Reservoir oil. Bottom hole samples of reservoir oil have been obtained from British American Marye 1 and Sunray Mid-Continent Federal C-21, NE NE Sec. 8-25N-12W. Both samples reflect similar characteristics. Bubble point pressures were respectively 1,155 psia and 1,260 psia at 145° F. Original reservoir pressure is estimated at 1,612 psig at +1,300 feet datum. Table 1 lists the significant physical characteristics of the Lower Gallup reservoir oil at the reservoir temperature of 145° F.

Production history of LPG pilot area. The four oil wells located at the intersection of Townships 25-26 North and Ranges 12-13 West provided a logical area for the LPG flood test. The input well was drilled in the center of the four oil well locations completing the pattern, after necessary agreements were completed between British American, Phillips, El Paso, Shell, Amerada and Sunray Mid-Continent as operator. LPG injection began on August 27, 1957.

During the period August 27, 1957, to September 19, 1957, 15,800 barrels of butanes followed by 15,215 barrels of propane were injected into the upper bench of the Lower Gallup. All LPG products were transported to the well site by trucks. Both the transportation and injection were handled by outside contractors. Injection of LPG averaged approximately 1,350 bpd and no difficulties were encountered in the injection.

Upon completion of injection of the LPG slug, gas injection began to drive the LPG slug toward the four producing oil wells. Total gas source was purchased during the early stages of

About the Author

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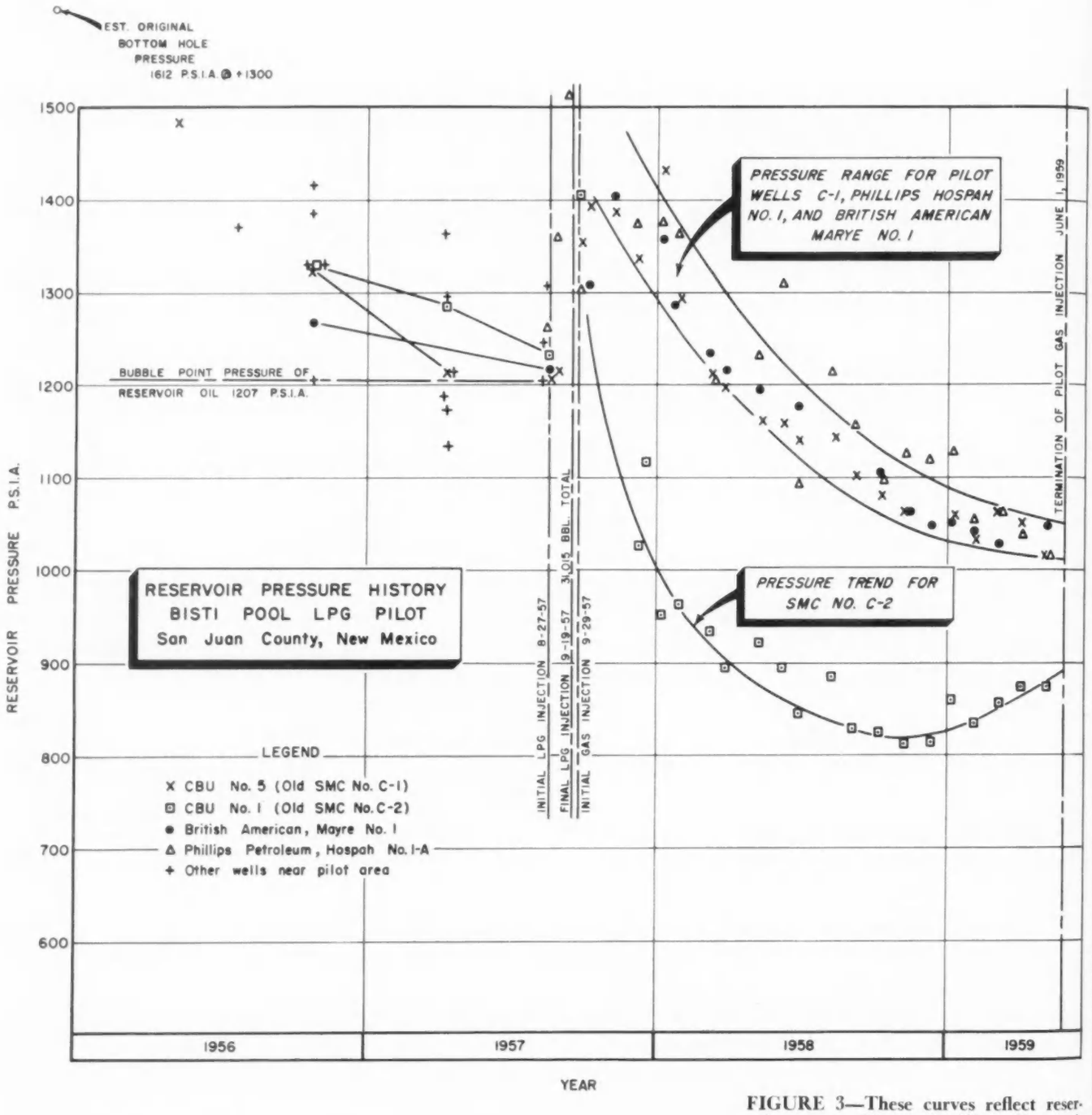

FIGURE 3—These curves reflect reservoir pressure history for Bisti pilot project. Unfavorable response of Federal C-2 was due to inferior rock character (See Figure 2).

the flood, but as gas-oil ratios increased, produced gas was gathered and compressed for injection and necessary make-up gas was purchased. This operating method was continued until May 30, 1959, when pilot operations ceased.

The reservoir pressure history of the four pilot oil wells is shown in Figure 3. As indicated, the LPG flood began before the average reservoir pressure in the pilot wells reached the bubble point pressure of 1,207 psia during the early depletion of the pool. Also, a reservoir pressure build-up of more than 200 psi is observed in the pilot wells after the injection of the LPG.

The decline in shut-in reservoir pressure trend for three of the four pilot oil wells is higher yet paralleled the decline trend for the area outside the pilot. Federal C-2, which represents inferior rock character consistent with edge locations, has responded unfavorably in pressure performance. Pressure interference, during the early pilot operation, was observed in wells from one-half mile to approximately one mile distant from the injection well; pressure build-up in the outlying wells varied from 50 to approximately 200 psi.

Production from the four-pilot oil wells was based on special allowable

Table 1—Characteristics of Lower Gallup Oil at Reservoir Temperature of 145° F.

Pressure, psia		Reservoir Oil Volume Factor R Bbl./Bbl. S.T. Oil	Solution Gas Content SCF/Bbl. S.T. Oil	Viscosity Centipoises
Bubble Point	1,207	1.26	407	0.83
	1,000	1.24	356	0.86
	800	1.22	311	0.93
	600	1.20	265	1.02
	400	1.18	215	1.13
	200	1.15	155	1.38
	100	1.13	115	1.65
	50	1.11	75	1.93
	14.7	1.04	0	2.65

granted by the New Mexico Conservation Commission. The total pilot allowable was allocated between the four oil wells on a voidage basis consistent with the acre feet of hydrocarbon pore space in each quadrant. The allowable was maintained until the gas production reached approximately 1.5 MMcfd which was the capacity of the compressors in re-injecting the produced gas. A detail listing of monthly oil production, produced gas-oil ratios and injected gas volumes are listed in Table 2.

Production performance of the four pilot oil wells is illustrated in Figure 4, which graphically illustrates the displacement of oil per barrel of reservoir voidage versus accumulated oil. Reservoir voidage, as the name implies, is the reservoir volume of produced reservoir oil plus free reservoir gas. These curves are characteristic in trend for any displacement mechanism and may be extrapolated for ultimate recovery estimates. It is noteworthy that initial breakthrough occurs when approximately 20 percent of ultimate recovery is achieved.

Results of the pilot performance were instrumental in forming the Central Bisti Unit in July 1959. **—The End**

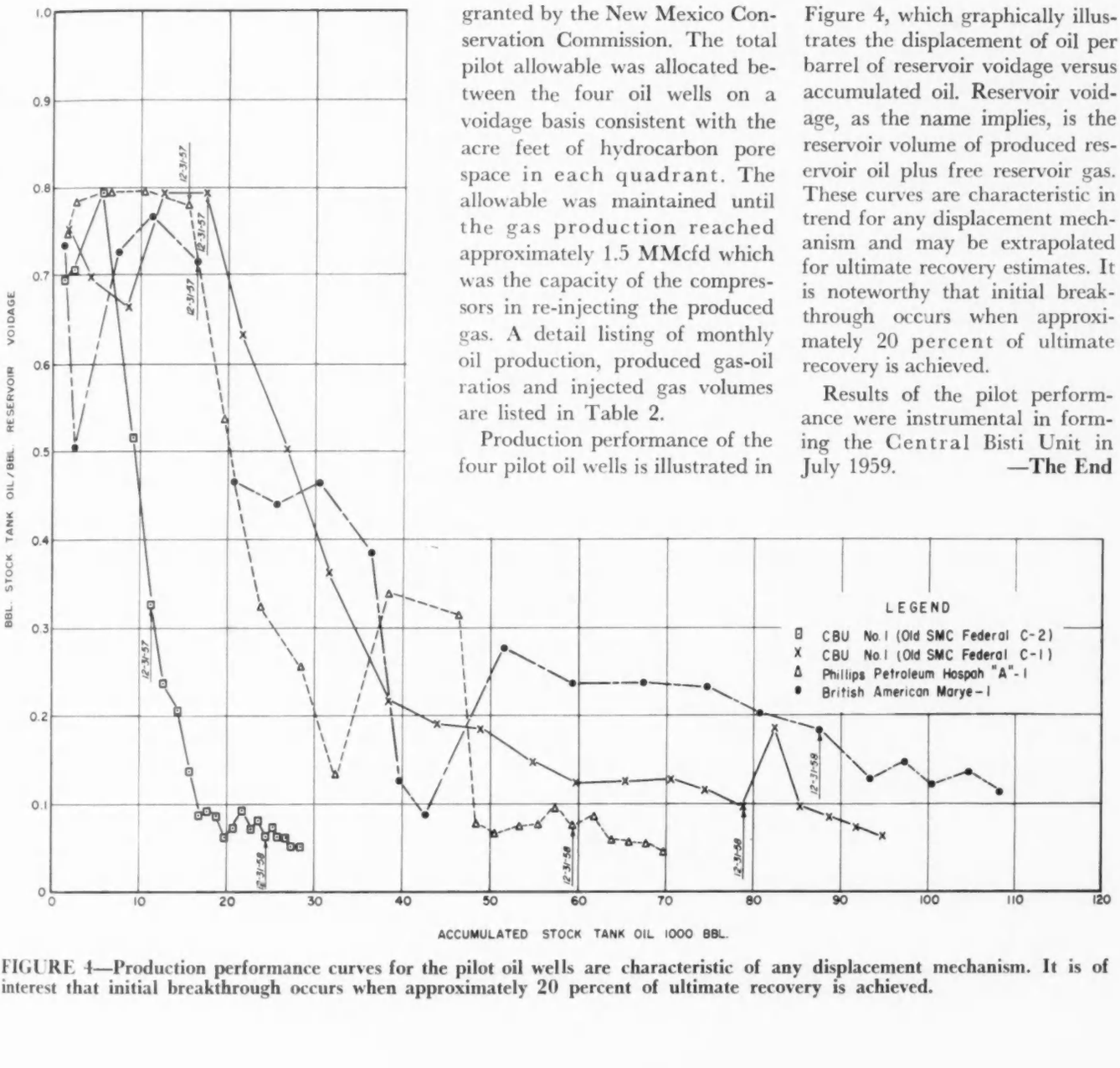

FIGURE 4—Production performance curves for the pilot oil wells are characteristic of any displacement mechanism. It is of interest that initial breakthrough occurs when approximately 20 percent of ultimate recovery is achieved.

Table 2—Production Statistics of Bisti Pool LPG Pilot Test.

DATE	Sunray Mid-Continent Federal C-1		Sunray Mid-Continent Federal C-2		British American Marye #1		Phillips Hospah #1-A		Gas Injection Well	
	Bbl. Oil	GOR	Bbl. Oil	GOR	Bbl. Oil	GOR	Bbl. Oil	GOR	MCF	Bbl. LPG
August—1957	1,998	460	1,317	511	1,018	475	1,681	465	.....	7,750
September	2,034	520	1,158	510	1,653	810	990	440	2,044	23,265
October	4,458	567	3,407	358	4,561	496	3,903	376	20,447	.....
November	4,110	413	3,142	684	3,814	453	3,779	335	14,433	.....
December	4,764	420	2,093	1,070	5,110	500	5,075	440	16,454	.....
January—1958	4,182	592	1,603	1,442	4,497	876	4,356	736	14,592	.....
February	5,101	787	1,645	1,579	4,950	924	4,053	1,335	13,410	.....
March	4,917	1,145	1,293	2,328	4,656	858	4,556	1,699	20,838	.....
April	6,645	1,964	1,172	3,571	5,945	1,044	3,683	3,345	31,563	.....
May	5,734	2,213	1,027	3,360	3,405	3,365	6,320	1,179	37,658	.....
June	4,961	2,232	1,079	3,499	2,969	4,742	7,623	1,271	32,650	.....
July	5,783	2,772	1,062	5,002	8,749	1,419	2,247	5,417	45,884	.....
August	4,898	3,266	880	3,986	8,011	1,646	2,198	6,093	44,720	.....
September	5,440	3,183	922	3,183	7,963	1,615	2,570	5,493	45,300	.....
October	5,388	3,033	950	4,131	7,485	1,647	2,141	5,084	43,931	.....
November	3,846	3,328	753	4,066	5,924	1,883	1,950	4,166	38,383	.....
December	4,589	3,937	903	4,579	6,756	2,060	2,291	5,139	40,645	.....
January—1959	3,509	2,943	782	3,909	5,693	1,997	2,474	4,424	33,322	.....
February	2,741	3,877	703	4,895	3,917	2,493	1,812	6,376	43,940	.....
March	3,651	4,446	770	5,088	4,307	3,086	2,174	6,752	50,084	.....
April	2,984	5,200	627	5,825	3,489	2,680	1,898	7,430	49,274	.....
May	3,226	5,958	763	6,274	3,338	3,322	1,990	8,942	58,251	.....
TOTAL	94,959		28,051		108,210		69,764		697,823	

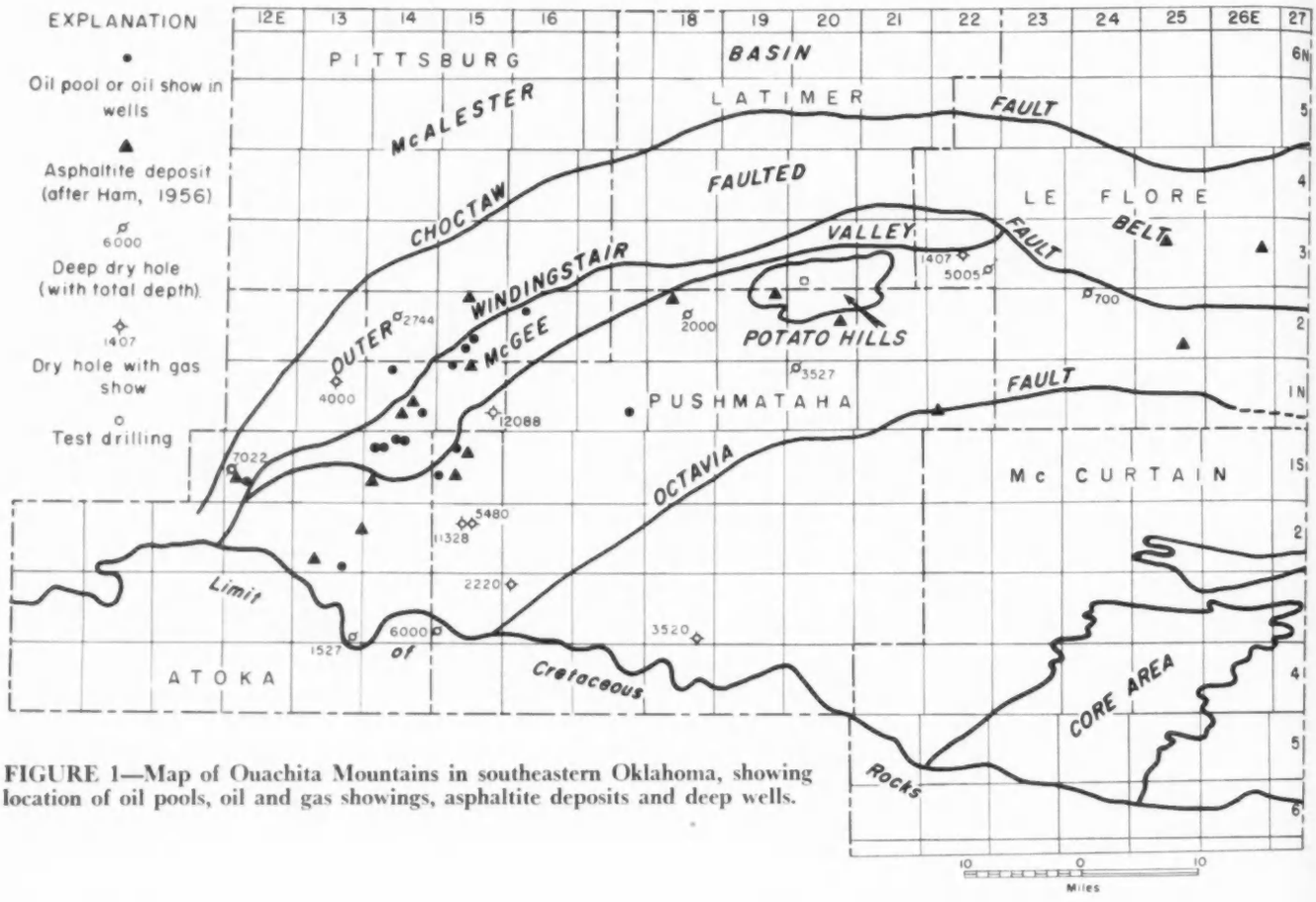

FIGURE 1—Map of Ouachita Mountains in southeastern Oklahoma, showing location of oil pools, oil and gas showings, asphaltite deposits and deep wells.

Ouachita Mountains DO have oil and gas potential

Oil, gas, asphaltite present; metamorphism exaggerated; structure unsolved

By Philip A. Chenoweth,
Assistant Professor,
School of Geology,
University of Oklahoma,
Norman

OIL AND GAS ARE PRESENT within the Ouachita Mountains province. The degree of metamorphism to which the sediments have been subjected has been exaggerated in the past. The high carbon ratio arguments previously used to condemn Ouachita prospects are inaccurate and their significance, if any, is not yet resolved. The author doubts that structural complexities condemn the area.

Hence, it may be only a matter of time before commercial deposits are discovered. This is significant, not only to the Ouachita Mountains, but also to the 900-mile Ouachita facies belt in Texas, and to the southward extension of the Arkansas Valley gas play, now crowding the Ouachita Mountain front.

The Ouachita Mountains of southeastern Oklahoma occupy a potential producing region of approximately 6,000 square miles. Reluctance of oil companies to venture for oil and gas in this province results from prejudices based on misinterpretation of facts. It is also due to the general dearth of knowledge of the geologic conditions within the mountains.

Reasons cited for reluctance to explore the area for oil and gas are as follows:

- High carbon ratios
- Rocks are metamorphosed
- Sandstones lack porosity
- No adequate source rock
- Pre-Atoka rocks are all silicified
- Extensive thrust faulting.

This discouraging outlook is not entirely justified. A little oil is now

being produced there. Serious exploration should result in new oil and gas pools.

Pessimism refuted. Following are explanations intended to refute the objections cited above:

1. **High carbon ratios.** The fixed carbon ratios to which critics most often refer are those of the Arkansas Valley-McAlester Basin and not of the Ouachita Mountains. In general, coals are rare in the Ouachita facies and carbon ratio analyses have not been made. That published maps show a great southward and southeastward increase in carbon ratio in the McAlester Basin is undeniable. And yet, large quantities of natural gas are being produced in areas of Arkansas and eastern Oklahoma where carbon ratios are as high as 80 percent—far beyond the theoretical "deadline" for gas.

Furthermore, as Levorsen has pointed out, there are many reasons (Levorsen lists nine) for doubting the reliability of such carbon ratio studies.[1]

If coals were widespread areally and stratigraphically, and analyses were made with careful regard to the geology of the coal and of the associated strata, it might be possible to produce a carbon ratio map that would be an accurate guide to prospecting. For the Ouachita Mountains, no such map exists.

2. **Metamorphism.** The widespread misunderstanding of the nature of the rocks in the Ouachita Mountains stems from Honess' statement that the rocks of the Ouachita facies are "profoundly metamorphosed."[2] Subsequent investigators have gradually reduced the concept of the degree of metamorphism to "low-grade metamorphism."[3] And even this stage of metamorphism appears to exist only in the area of the core of the mountains in McCurtain County, Okla., and adjacent parts of western Arkansas.

In the outer belt of the mountains there has been no detectable metamorphism. Many of the Stanley sandstones may be described, moreover, as "poorly cemented" or "friable." Shales deserve the designation of "clay shales," "fissile" or "flaky." None of the rocks can be properly classed as metaquartzite, phyllite, slate or marble, the common metamorphic equivalents of sandstone, shale, and limestone.

3. **Lack of porosity.** In some test wells in and near the mountains the sandstones have been noted as generally non-porous or only slightly porous. Similar observations have been recorded at surface exposures. In this instance also, critics of the region have made this an all-inclusive generalization leading to condemnation of a large area. This is a grossly misleading proposition. Even within the core area the sandstones are porous, although the porosity is localized in zones or beds separated by non-porous intervals.

Sandstones of the outer belt of the mountains are no more tightly cemented than they are in many of the producing areas of south-central Oklahoma. Indeed, it is difficult to distinguish a hand specimen of a Stanley sandstone from one of a Springer sandstone of south central Oklahoma. Much of the Stanley sandstone contains quantities of clay-like interstitial matter which tends to reduce primary porosity. This in itself should not be regarded as a wholly unfavorable factor in the light of oil and gas production. True, graywacke reservoir rocks are known in many areas of the country, notably in Pennsylvania and along the Gulf Coast.

A comparison of electric logs and samples from wells along a line from the Max Pray Wyrick 1, 26-1n-14e to the Tom Potter Ellis 1, 31-5s-16e, almost across the entire exposed portion of the Ouachita Mountains in Oklahoma, reveals a considerable increase in grain size, porosity, and friability of the Stanley in a southerly direction.

4. **Lack of source beds.** A region in which the rocks consist predominantly of eugeosynclinal facies (slates, graywackes, siliceous rocks and pyroclastics) has always been considered an unprofitable area in which to prospect for oil and gas. "Source beds," a term glibly used but inadequately defined in the literature, are considered to be necessary for an oil province. The environment most likely to produce source beds (presumably organic-rich strata) is the Continental Shelf. The Ouachita Mountains area has often been described as eugeosynclinal in nature; and yet, the great bulk of older (pre-Mississippian) sediments are unexposed except for a few small inliers. And even within the core area of McCurtain County many of the strata exhibit characteristics typical of the Shelf environment.[2] Misch and Oles have pointed out that the apparent contrast between the rocks of the Arbuckle facies (proven to be excellent "source beds") and the Ouachita facies, at least insofar as the exposures in Black Knob Ridge and the Potato Hills are concerned, is due more to an unfortunate dual nomenclature than to any real differences.[4] A further point lies in the possibility that rocks of the miogeosyncline (Arbuckle facies) and Shelf may lie beneath the "eugeosynclinal facies" and thus provide adequate, though deeply buried, source beds.

5. **Silification of pre-Atoka rocks.** Chert and novaculite form a significant proportion of the pre-Pennsylvanian strata in the Ouachita Mountains. The Jackfork and Stanley groups contain extensive, though relatively thin, siliceous shales; the Stanley encloses a tuff lentil in the core area. The most prominent and widespread siliceous rock is the Arkansas novaculite. This formation in part grades westward into the Woodford shale of the Arbuckle area with which it is identical. Harlton has pointed out that strata in the oil region of the Ardmore Basin are similar to the lower middle Arkansas novaculite.[5] The Santa Maria district of California, from which nearly 250 million barrels of oil have been drawn, produces from a similar siliceous rock (Monterey shale) and the reservoir rock of some West Texas oil pools is the Caballos novaculite, considered the westward equivalent of the Arkansas novaculite of the Ouachita Mountains. The mere presence of siliceous rocks is not, therefore, to be considered as enough to condemn the region.

6. **Extensive thrust faulting.** The very presence of thrust faults of great magnitude in the Ouachita Mountains area is a subject of considerable dispute. Pitt has shown that the area in McCurtain County, previously mapped as a fenster, is in reality a relatively simple anticlinal uplift.[3] Misch and Oles propose a similar explanation for the fenster in the Potato Hills.[4] Hendricks, on the other hand, has taken exception to many of the points brought out by Misch and Oles.[6]

The presence or absence of thrust faults, however, has little bearing on the oil and gas possibilities of the area. They can, of course, enormously snarl the job of structure mapping and complicate the life of the development geologist. But enough oil

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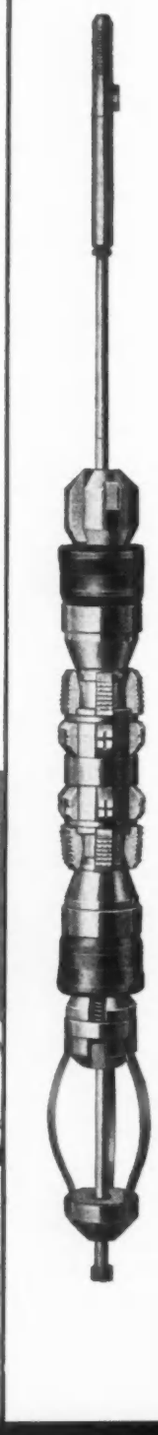

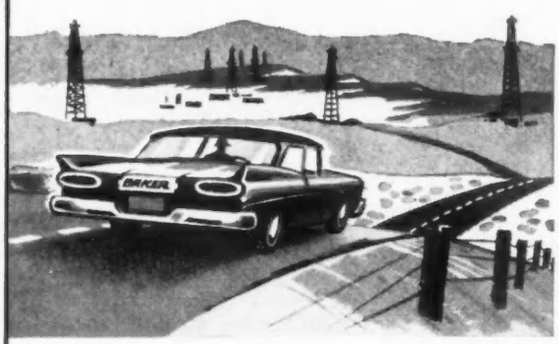

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pools of the world are situated in thrust-faulted regions (i.e., Turner Valley, Alta., and Rose Hill, Va.) to contradict the assertion that thrust faulting is sufficient to condemn the province.

Oil shows. Oil actually is being produced from a few small pools within the Ouachita Mountains. Perhaps the best known occurrences are those along the floor of the McGee Valley in Atoka and Pittsburg Counties. The Redden pool (now abandoned) was located in 1s-14e, about a mile south of the settlement of Redden, producing from a Stanley sandstone bed. The trap is apparently affected by an asphalt seal, as the producing zone crops out within a few feet of the wells. The field was discovered in 1914. About 15 wells have been drilled, ranging in depth from 90 to 350 feet. The oil is 36 gravity and was produced at a total rate of eight to nine barrels per day from three active wells.

Five producing wells are located on the flanks of a small fold in 33-2n-15e and 5-1n-15e, in the Bald pool. This production is likewise from the Stanley sandstone, at a depth of about 185 feet. The trap is probably stratigraphic since the wells appear to be quite far down on the limbs of an anticline. The oil is dark green, 42 gravity, and is pumped at a rate of one or two barrels per day.

Oil was found at a depth of approximately 450 feet in three wells in

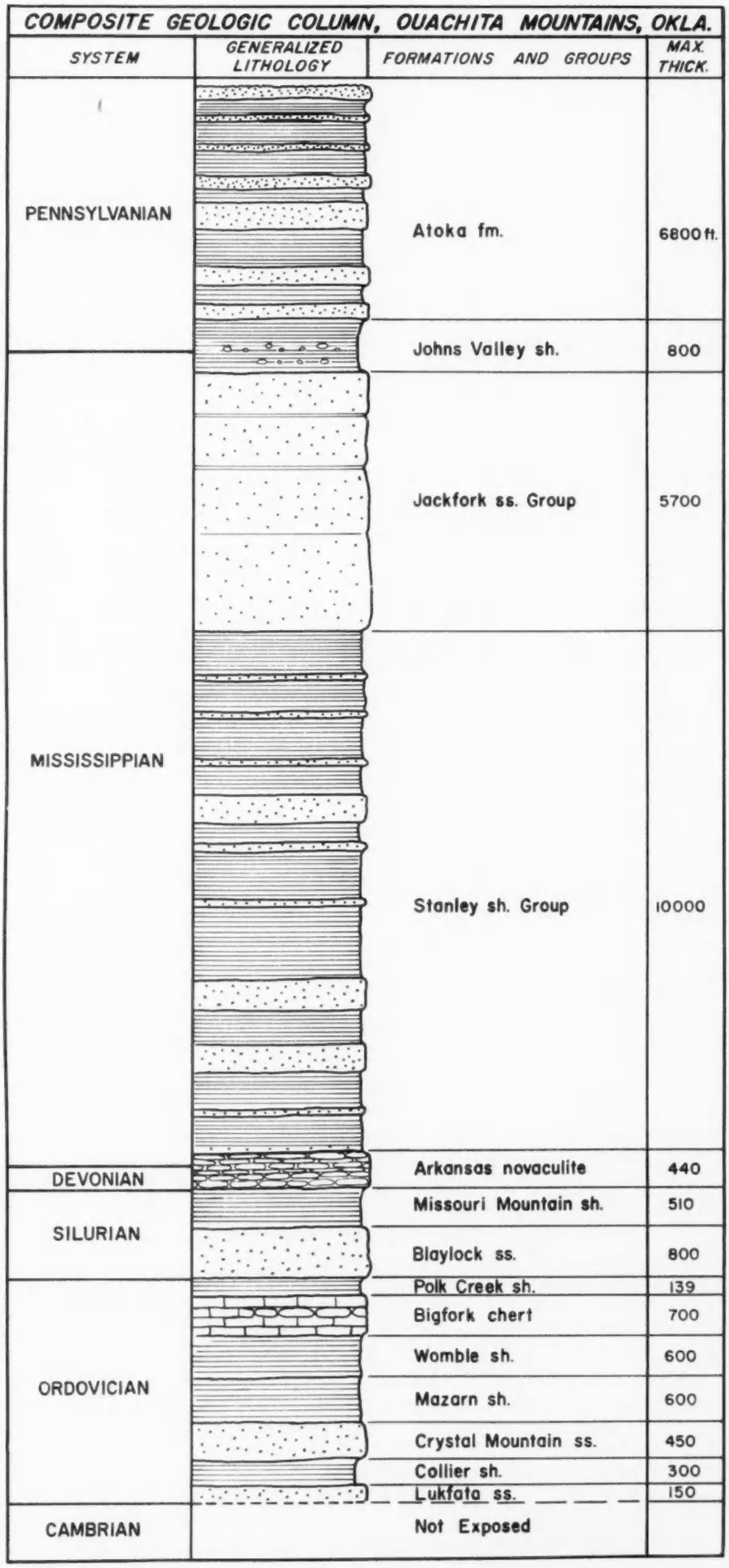

FIGURE 2—This sedimentary column shows alternating sandstones and shales of the Atoka formation at the top. The Atoka has produced large quantities of hydrocarbons in the Mid-Continent and many recent gas discoveries in Arkansas are in the Atoka. Asphaltite deposits have been found in the Jackfork group and the Stanley, and some oil and gas also has been found in the Stanley. Solid hydrocarbons are found in the Arkansas novaculite, and Bigfork chert. In recent months gas was found in the Bigfork also. In some cases, the distinction between Arbuckle and Ouachita facies is not clear.

35-2s-13e, Atoka County. Here also the production is obtained from Stanley sandstone. The location is along the northwest limb of a large syncline, close to a thrust fault. The oil is 25 gravity; during initial tests the well pumped at rates from 4 to 15 barrels per day. The field, discovered in 1932, has since been abandoned.

A well drilled in 1950, near the town of Stanley in 26-1n-17e, is reported to have produced as much as 10 barrels of 52 gravity oil per day. An offset well was dry and the first well has been abandoned. This location is in the Kiamichi Valley, a long asymmetrical anticlinal fold east of the prominent Tuskahoma syncline. Oil was found at a depth of 345 feet in the Stanley sandstone.

Numerous other tests in the Ouachita Mountains have reported oil shows, particularly in McGee Valley. The valleys of McGee Creek, Buck Creek and North Jackfork Creek form a nearly continuous lowland (collectively known as McGee Valley) extending from a point about five miles south of Redden in 1s-14e northeast to and beyond the settlement of Weathers in 2n-17e. This lowland is located in structures essentially anticlinal in nature, though it lies between the Windingstair and Jackfork Mountain faults in an area where faulting and tight folding is the rule. A long strike fault splits the valley in two. The greatest number of test wells has been drilled in this valley and it is the only area in the Ouachita Mountains in which oil is currently produced.

No active oil seeps are known in the Ouachita Mountains, but Ham reports that some of the asphaltite deposits appear to be softer at depth and more petroleum-like.[8] These solid hydrocarbon deposits occur as veins and dikes at many small localities in the outer part of the mountains, most of them in the Stanley and Jackfork groups, though others have been noted in the Bigfork chert and in the Arkansas novaculite.

Gas shows. A few wells in the Ouachita Mountains area have encountered shows of natural gas. The Sikes-Burkhalter's Denton-Perrin 2 in 9-2s-15e was drilled in 1958, in an attempt to exploit gas sands encountered in Southwest Exploration's Perrin 1, in the same section. Several non-commercial shows of gas were tested in the Stanley sandstones, and the well is now flaring gas, but abandoned.

Max Pray's Wyrick 1 in 26-1n-14e, near Daisy in the McGee Valley, tested two gas sands in the Stanley, one of which flowed gas at the rate of 200,000 cubic feet per day, the other at 300,000 cubic feet per day. No analyses of the gas in these wells are available but it is assumed to be dry gas. Hendricks et al reports that a well in the Potato Hills area in Latimer County struck a small flow of wet gas.[9]

Shawnee Drilling Company Moyers 1 in 6-3s-16e, near the town of Moyers, is at present bubbling sizeable quantities of gas, presumably leaking around the plugged surface casing from a source in the Stanley. Sinclair Reneau 1 in 33-3n-20e in the Potato Hills had drillstem tested commercial shows of gas in the Bigfork Formation. This rank wildcat was scheduled to go to 8,000 feet to test the Crystal Mountain sandstone.

About the Author

Philip A. Chenoweth, a native of Chicago, is a Columbia University graduate, holding B.A., M.A., and Ph.D. degrees in geology. He received his doctorate in 1949. He was employed by Sinclair Oil Corporation from 1946 to 1949, receiving such varied experience as research on East African geology and field work in Wyoming and Idaho. After two years as geology instructor at Amherst College, Chenoweth rejoined Sinclair as assistant district exploration geologist in Ardmore, Okla. He left this post in 1954 to become assistant professor of geology at the University of Oklahoma. In addition, he is a consultant to several oil companies. Chenoweth is an active AAPG member and a fellow of the GSA.

Summary. If it is assumed that high pressures and elevated temperatures (resulting from intense diastrophism and metamorphism of rock) tend first to convert low-grade petroleum or organic matter to higher-grade petroleum; and second to expel the lighter oil and gas from the area of activity leaving a residue of asphalt, it is difficult to explain the present conditions in the Ouachita Mountains. Here are found not only the solid hydrocarbon "residues" in several forms, but also a wide range of oils and gases. If a slow distillation process has been responsible, as suggested by Rich,[7] it is not only impossible to explain the very presence of oil and gas, but also, to account for the downward softening of the asphaltite deposits, since presumably the metamorphism would be more intense at depth.

On the other hand, if the oil and gas and asphaltite are present in the rocks without having been distilled to any great degree, all of the conditions are explainable. Presumably, the liquids and gases are held within porous zones in the reservoir strata in the way common to that of the post oil-producing regions. Some has reached the surface through fractures or as a result of erosion, to become hardened by a slow loss of volatiles; still more *must* remain trapped below. Whether or not the actual source of the petroleum in all its forms is within Ouachita facies or in Arbuckle facies beneath has little bearing on the problem.

ACKNOWLEDGMENT

The author thanks the Oklahoma Geological Survey for permission to publish this paper.

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PART 2: Sample Calculations

How to design a closed rotative gas lift system

By H. W. Winkler, Engineer
Camco, Incorporated, Houston

A CLOSED ROTATIVE gas lift system for a single intermittent well represents the worst possible operating conditions, particularly if a time cycle surface controller is used on the injection gas line. Design of this one well system, which will operate without make-up gas after the system is initially charged, will illustrate all calculations and design considerations required for intermittent wells with time cycle surface controllers. The following data will be used for designing a closed rotative system for a single intermittent well.

Depth of operating valve	= 5,000 feet
Daily producing rate	= 48 bopd
Formation producing gas-oil ratio	= 600 cu.ft./bbl.
Injection gas for 2 min. every 30 min.	(48 cycles/day)
Production per cycle	= 1 bbl. oil/cycle
Injection gas requirement per cycle	= 2,000 cubic ft./cycle
Operating injection gas pressure	= 500 psig
Compressor suction pressure	= 30 psig
Compressor discharge pressure	= 650 psig
Compressor gas inlet temperature	= 100° F
Injection gas gravity	= 0.6
Injection gas pressure and temperature base	= 14.65 psia and 60° F.
Average temperature of gas in low and high pressure systems	= 100° F.
Sales line regulator opening pressure	= 60 psig
Estimated unaccountable gas loss in system	= 4% of deliverability of compressor
Size and length of injection gas line	= 2 in., 1,000 ft.
Obtain volumes of gas-out from orifice meter chart in Figure 2.	

Several steps have been simplified in the following example calculations by giving certain information which normally would be calculated. These calculations are offered to illustrate how to design a closed rotative system rather than how to figure individual well and compressor problems. For this reason, such items as injection gas requirement and compressor suction and discharge pressures were given rather than calculated.

A. Estimation of daily injection gas requirement

Daily injection gas requirement at standard conditions to lift wells
= 2,000 cu.ft./cycle (48 cycles/day)
= 96,000 cu.ft./day at 14.65 psia and 60° F.

Total Daily Gas Reqmt. at Std. Cond. Including Unaccountable Losses
= 96,000 (1.04)
= 99,840 cu.ft./day at 14.65 psia and 60° F.

Where: 1.04 = Factor for including unaccountable gas loss in system of four percent.

B. Calculation of approximate compressor brake horsepower

From a manufacturer's compressor bhp curves for 30 psig suction pressure and 650 psig discharge pressure:[4]

Approx. bhp/MMcfd at 14.4 psia and Intake Temp. of 100° F = 182 bhp.

Daily injection gas requirement at 14.4 psia and 100° F.

$$= 99{,}840 \left(\frac{14.65}{14.4}\right)\left(\frac{560}{520}\right)$$

= 109,400 cubic feet/day at 14.4 psia and 100° F.

Approximate compressor bhp $\cong 182\left(\frac{109{,}400}{1{,}000{,}000}\right) \cong 20$ bhp

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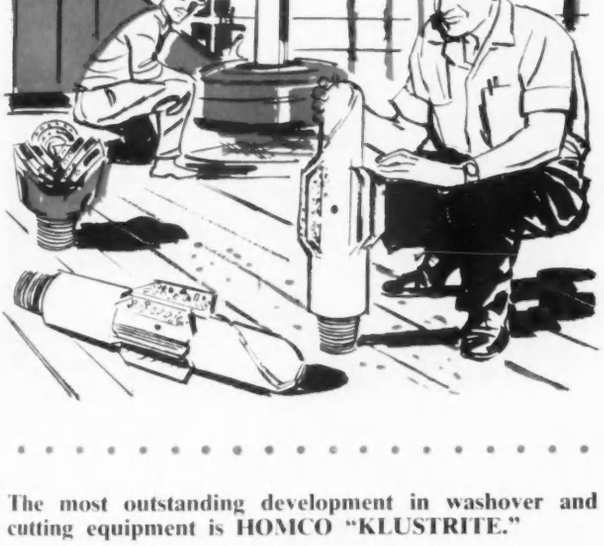

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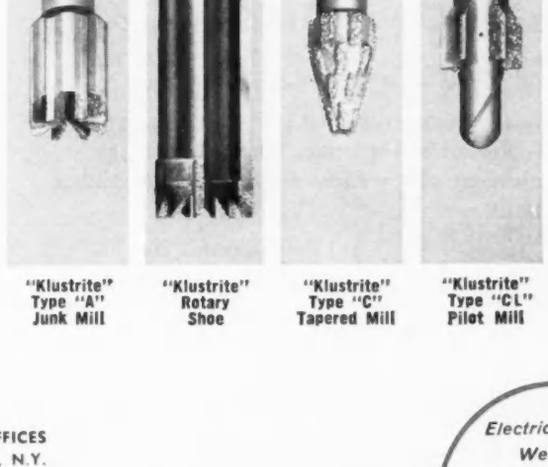

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SEQUENCE OF EVENTS: No. 1 to No. 2—Liquid slug entered flow line and traveled to separator; No. 2 to No. 3—Liquid slug entered separator; No. 3—Injection gas immediately behind liquid slug began to enter separator; No. 3 to No. 6—Total injection and formation gas behind liquid slug entered separator.

GAS VOLUMES: No. 3 to No. 4—Injection and formation gas volume = 1,300 cu. ft. No. 2 to No. 5—Injection and formation gas volume = 1,840 cu. ft. No. 1 to No. 6—Total injection and formation gas volume per cycle = 2,600 cu. ft.

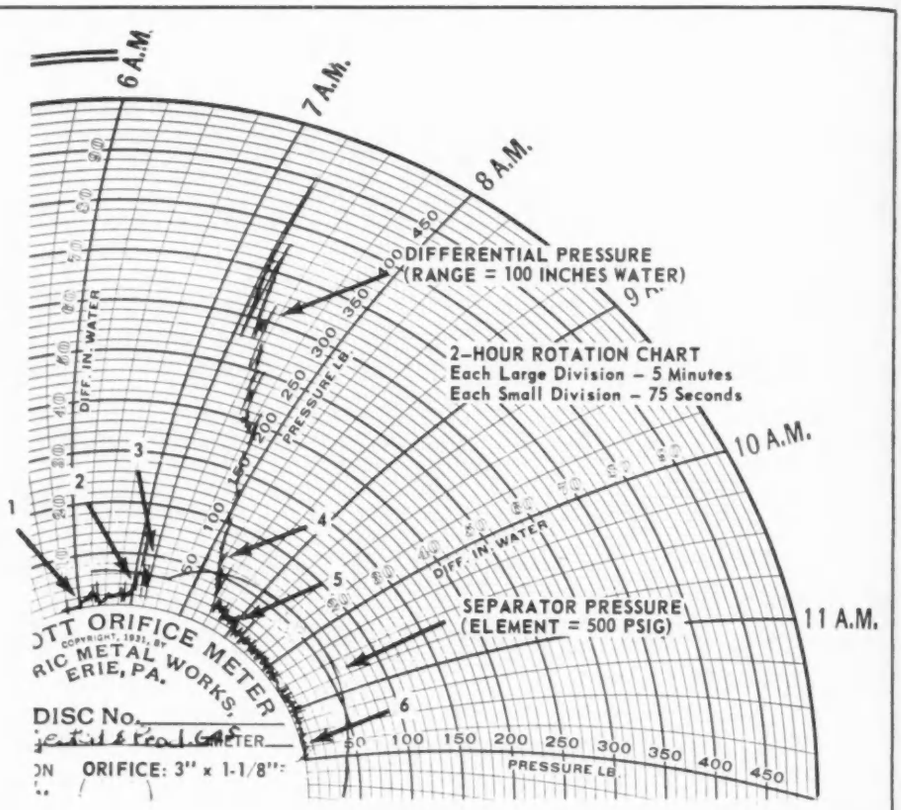

FIGURE 2—Quarter section of low pressure sales line two-hour rotation orifice meter chart of total volume of gas-out (injection and formation) per cycle from intermittent gas lift well.

C. Design of high pressure injection gas system

1. Per-minute compressor deliverability
$= \frac{99{,}840 \text{ cubic feet/day}}{1{,}440 \text{ minutes/day}} = 69$ cu.ft./min.
2. Injection gas volume required from HP system
= 2,000 cu.ft./cycle — 2 minutes (69 cu.ft./min.)
= 1,862 cu.ft.
3. Approximate capacity of HP system using Equation 1:
$$1{,}862 = \left[\frac{650 - 500}{14.65}\right] \text{Capacity}$$
Capacity = 182 cubic feet.
4. Approximate pressure loss in HP injection gas line using Weymouth's Alignment Chart:[5]
Daily injection gas volume based on per minute requirement
$= \left(\frac{2{,}000 \text{ cu.ft./cycle}}{2 \text{ minutes/cycle}}\right)(1{,}440 \text{ minutes/day})$
= 1,440,000 cu.ft./day at 14.65 psia and 60° F.
$= 1{,}440{,}000 \left(\frac{14.65}{14.4}\right)\left(\frac{560}{520}\right)$
= 1,578,000 cu.ft./day at 14.4 psia and 100° F.
From alignment chart $(P_1^2 - P_2^2) = 12{,}800$
$(P_2)^2 = (664.65)^2 - 12{,}800$
$= 441{,}800 - 12{,}800 = 429{,}000$
$P_2 \cong 655$ psia $\cong 640$ psig (Pressure Loss Negligible)

D. Calculation of excess or make-up gas volume

1. Daily produced formation gas
= 48 bbls. oil/day (600 cu.ft./bbl.)
= 28,800 cu.ft./day
2. Daily compressor fuel requirement
= 10 cu.ft./bhp-hr. (24 hr./day) 20 bhp.
= 4,800 cu.ft./day
3. Estimated unaccountable losses in system
= 0.04(96,000) = 3,840 cu.ft./day
4. Estimated excess daily gas volume which can be sold or vented
= 28,800 — 4,800 — 3,840
= 20,160 cu.ft./day

E. Design of low pressure gas gathering system

1. Volume of gas entering LP system during period of time that compressor capacity is exceeded from Figure 2:
Approximate orifice meter reading = 60 psig and 2 inches when gas volume ≅ 100 Mcfd ≅ compressor capacity
Compressor capacity exceeded from points (2) to (5)
Approximate gas volume between points (2) and (5)
= 1,840 cu.ft. in 10 minutes
2. Volume of gas required for deliverability and fuel requirement of compressor during same period
$= \frac{104{,}640 \text{ cu.ft./day (10 min./cycle)}}{1{,}440 \text{ min./day}}$
= 727 cu.ft./cycle

Where: Deliverability = 99,840 cu.ft./day
Fuel requirement = 4,800 cu.ft./day
Total = 104,640 cu.ft./day

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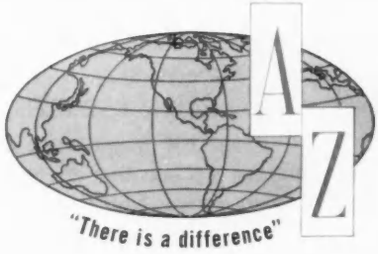

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3. Volume of excess gas which can be sold or vented per cycle
$= \frac{20{,}160 \text{ cu.ft./day}}{48 \text{ cycles/day}} = 420 \text{ cu.ft./cycle}$

4. Volume of gas to be stored in LP system
$= 1{,}840 - 727 - 420 = 693$ cu.ft. at 14.65 psia and 60° F.
$= 693 \left(\frac{560}{520}\right)$
$= 746$ cu.ft. at 14.65 psia and 100° F.

5. Approximate capacity of LP system using Equation 1:
$746 = \left[\frac{60 - 30}{14.65}\right]$ Capacity
Capacity $= 363$ cu.ft.

Effect Of Additional Wells In System

A detailed flow diagram of a closed rotative gas lift system for a multi-well installation is shown in Figure 3. The effect of additional wells in a closed system, as illustrated in Figure 3, is shown in Tables 1 and 2. The tabulations are based on the following assumptions:

1. Well data for all wells are assumed the same as that used for the previous single well calculations.
2. The two-minute periods of gas injection for each well are perfectly staggered in relation to the injection gas periods for the other wells. In other words, a central time-operated programmer is controlling the injection gas cycle frequency and duration of gas injection for all wells.

Several conclusions are apparent from the tables. As the number of wells in the system increases, the importance of the capacity of the high and low pressure systems decreases. Actually, the high pressure injection gas and low pressure gas gathering systems increase in capacity as more wells are included in the system.

This is one factor that reduces the operating problems in large systems.

Calculations for the high pressure system with several intermittent wells are straightforward as can be seen in Table 1, but calculations for the gas gathering system are not. Since the volume of total gas-out does not enter the low pressure system instantaneously following surfacing of the liquid slug, the capacity of the gathering system for several intermittent wells generally will be adequate due to flow lines, separators, suction lines, etc., provided the liquid slugs enter the system alternately.

TABLE 1—High Pressure Injection Gas System

Number of Wells in System	Daily Injection Gas Requirement (Mcfd)	Deliverability of Compressor During 2-Minute Injection Period (cu. ft.)	Injection Gas Volume from HP System (cu. ft.)	Approximate Required Capacity of HP System (cu. ft.)
1	96	138	1862	182
2	192	276	1724	168
4	384	552	1448	141
8	768	1104	896	88

TABLE 2—Low Pressure Gas Gathering System

No. of Wells in System	GAS VOLUMES DURING TIME COMPRESSOR CAPACITY EXCEEDED				Approximate Required Capacity of LP System (cu. ft.)
	Estimate Volume Entering LP System (cu. ft.)	Volume for Deliverability, and fuel (cu. ft.)	Excess Volume to Be Sold or Vented (cu. ft.)	Injection Volume to be Stored in LP System (cu. ft.)	
1	1840	727	420	693	363
2	1300*	727	420	153	81

* Assume volume of total gas-out for each cycle has entered low pressure system before next cycle begins which is not exactly correct as can be seen from Fig. 2.

The difference between a liquid slug entering the system every 30 minutes and every 15 minutes can be illustrated using the orifice meter chart in Figure 2. Calculations for the low pressure system in which an injection gas cycle occurs every 30 minutes were given in the design of the one well system. When this system is increased from one well to two wells, the injection gas cycle frequency increases from 48 to 96 cycles per day or an injection gas cycle every 15 minutes. The total injection gas requirement or the two wells is approximately 200 Mcfd. Therefore, the compressor capacity is exceeded between points 3 and 4 in Figure 2. Compressor capacity is exceeded for 5 minutes, at which time approximately 1,300 cubic feet of gas would enter the low pressure system. Actually, slightly more gas than the 1,300 cubic feet would enter the low pressure system during this interval because some gas would still be entering the system from the other well, as can be seen from Figure 2. Neglecting this small volume of gas from the other well and the difference in the change in separator pressure for the two well system as compared to the one well system, the approximate required capacity of the low pressure system would decrease from 363 cubic feet to 81 cubic feet, as given in Table 2.

If a third well were added to the system and the periods of gas injection were synchronized, a liquid slug would be entering the separator every 10 minutes. Therefore, the capacity of the low pressure system would be of little or no concern for a 30 psi difference between maximum and minimum pressure in the gas gathering system.

The one factor which affects the validity of all calculations related to the high and low pressure systems for intermittent wells in a closed rotative system is synchronization of the time cycle surface controllers on the injection gas lines. It is difficult, if not impossible, to keep the periods of gas injection synchronized with individual clocks in the time cycle pilot on the surface controllers. A programer is the only positive way of synchronizing the injection periods. Generally, solenoid valves which are operated by a central programer are recommended as pilots for the surface controllers.

To illustrate the importance of synchronization of the injection gas cycles, the effect of two simultaneous gas injections in a four-well system, similar to that shown in Figure 3, will be calculated. The daily injection gas requirement of 384 Mcfd and deliverability of the compressor during the two-minute period of 552 cubic feet in Table 1 would not change. The approximate capacity

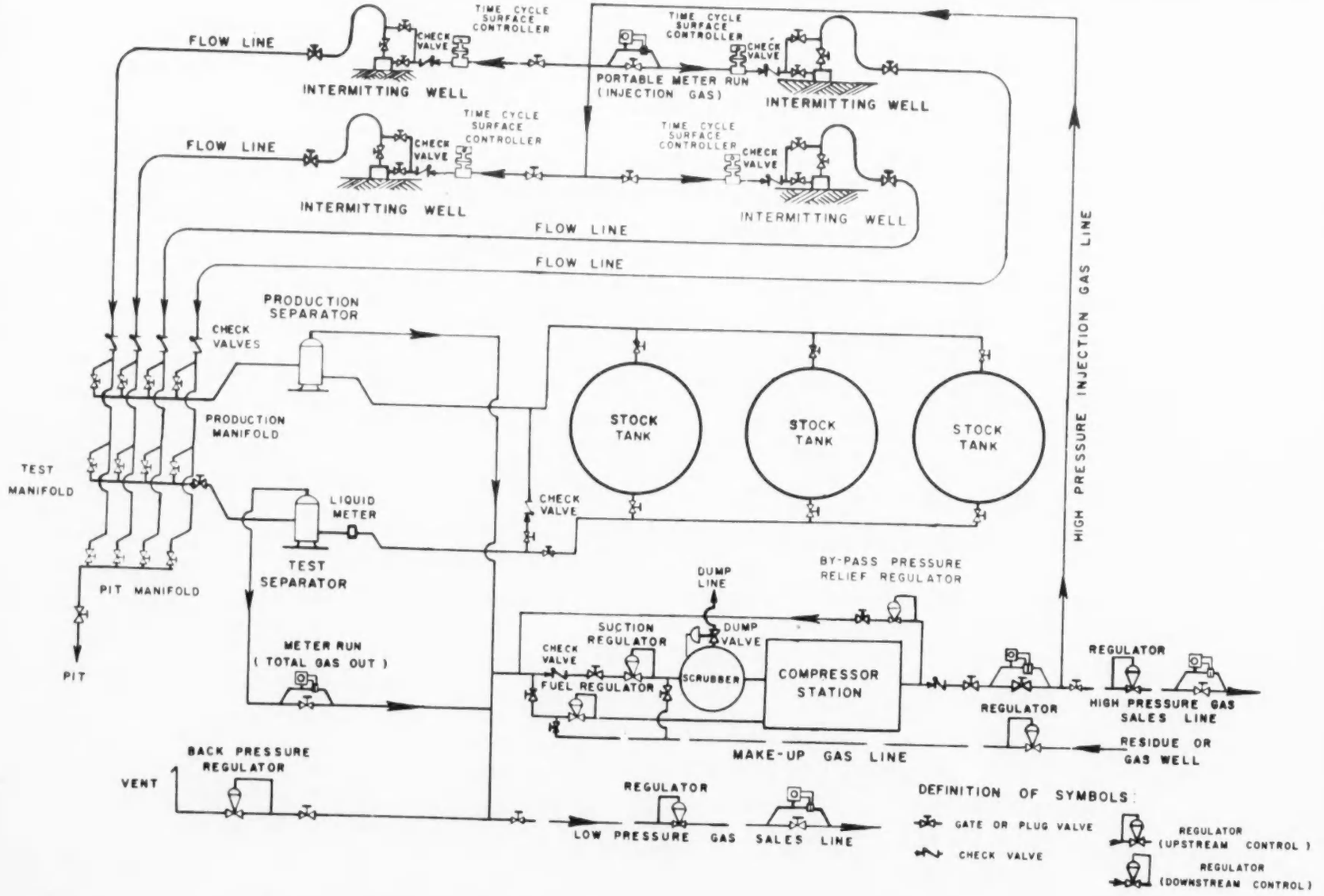


FIGURE 3: DETAILED FLOW DIAGRAM OF CLOSED ROTATIVE GAS LIFT SYSTEM FOR MULTI-WELL INSTALLATION

of the high pressure system required to supply adequate injection gas volume for lifting both wells at the same time could be calculated as follows:

Injection Gas Volume Required from High Pressure System:

$$= 2\ (2{,}000\ \text{cu.ft./cycle} - 552\ \text{cu.ft./cycle})$$
$$= 3{,}448\ \text{cu.ft./cycle}$$

Approximate capacity of high pressure system using Equation 1 (See Part 1):

$$3{,}448 = \left[\frac{650 - 500}{14.65}\right] \text{Capacity}$$

$$\text{Capacity} = 337\ \text{cu.ft.}$$

The capacity of the high pressure system would have to be increased nearly 2.4 times in order to supply the injection gas for simultaneously lifting two wells in the four-well system. If the high pressure system had only 141 cubic feet, as shown in Table 1, neither well would have received sufficient injection gas during that cycle for lifting the slug, and the production from both wells for this cycle would have been lost.

If surface controllers had opened two minutes apart instead of opening together, the well with the surface controller opening first would have received 2,000 cubic feet of gas but the other well would have obtained only the deliverability of the compressor during the injection cycle, or 552 cubic feet. In small systems with intermittent wells employing time cycle surface controllers, the injection gas cycles must be synchronized or the high pressure system large enough to assure adequate injection gas volumes every injection cycle.

The low pressure system in a small installation presents a design problem similar to the high pressure system if more than one slug enters the separator at the same time. The time cycle controllers can be synchronized and prevent this occurrence. However, when the high pressure gas is injected continuously through a small choke, the opening of the gas lift valve in the well cannot be positively controlled at the surface.

If slugs from two wells in the four-well system should enter the separator at the same time, the capacity of the low pressure system can be determined using the data for the two-well system in Table 2. Conditions would be similar to the two-well system except that twice the volume of gas would enter the low pressure system and the compressor deliverability, fuel consumption and unaccountable losses would be doubled. Therefore, twice the capacity of the low pressure system for two wells would be required.

In other words, the low pressure system would have to have a capacity of 162 cubic feet to prevent selling or venting injection gas which should have remained in the system. If the injection gas cycles were synchronized, the capacity of the low pressure system would have been of no concern.

Conclusions

Small closed rotative gas lift systems with intermittent wells require proportionately larger low pressure gas gathering and high pressure injection gas systems than large systems when time cycle surface controllers are used. These small systems should be carefully designed if make-up gas is costly and a central programer is not used.

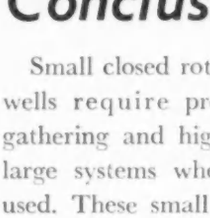
Central programers should be considered for small closed rotative systems with intermittent gas lift wells for synchronizing the injection gas cycles. Synchronization of the injection gas cycles assures that each well receives adequate injection gas volume at the designed operating injection gas pressure and no gas is vented or sold from the low pressure system due to several wells being lifted simultaneously.

Synchronization of the injection gas cycles is not imperative in large systems due to the greater number of wells and the large capacity of the high and low pressure systems. As a closed rotative system increases in size, operating problems diminish, provided the system is properly designed.

An operator who is designing a closed rotative gas lift system should consult other papers on this subject for additional specific design considerations.[4, 6]

This article is an expanded version of a paper presented to The West Texas Oil Lifting Short Course at Texas Technological College, Lubbock, Texas, in April 1960.

About the Author



H. W. Winkler is a graduate of Southern Methodist University with a degree in mechanical engineering. After working for The Atlantic Refining Company from 1948 to 1952 as a production engineer, he joined Camco Gas Lift Company in West Texas as a sales engineer. He came to Houston with Camco, Incorporated, as assistant chief engineer of gas lift in 1954. At present he is doing graduate work at the University of Houston. He is a registered professional engineer and a member of AIME.

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FOLLOWING A TREND of recent years, it is currently popular to admonish the American business leader that the pace of his life is killing him.

He is beset by social and economic pressures which seem to degrade successful accomplishment and make him appear almost a sinner. All sorts of measures and negative incentives are set up to remove temptation and make certain that the sin of success, if not actually punished, is certainly not to be rewarded.

He is threatened by such scare statements as "your next promotion may be your last." Others encourage him to be proud of his ulcer, to wear it as sort of a businessman's "purple heart," as though it were a sign of virtue, of devotion to a cause beyond the call of duty. Gratuitous advice tells him to slow down, take it easy, take longer vacations, don't work so hard.

Many businessmen are frightened by all this advice and find themselves in a neat trap. They have achieved their positions through hard work and aggressiveness. They have had almost boundless energy to expend and found great satisfaction in the struggle. What are they to do now? Give up?

The poor misguided wretch who happens to enjoy work is in an even worse fix for, by implication, to continue is suicide.

In view of these circumstances, it might be useful to re-evaluate some of these conclusions in view of available data.

Statistics vs. advice. The last half-century has seen an increasing extension in man's life from 48 years in 1900, until it is something over 70 plus today. This extension has taken place during the most productive era this nation has known.

Rules of hygiene and nutrition have been learned and implemented; man can manipulate his environment for greater comfort, security and safety than could his forefathers, in even one generation past. By accepted concepts, the wear and tear on his body should have become less as he learned to protect himself.

The businessman, having no special claim to immortality, also succumbs eventually just as everyone else. Coincidental with the increased span of life, there has been a change in the nature of conditions causing his inevitable departure. The infectious diseases have been replaced by what are called stress diseases or degenerative diseases and cancer. Accidents have moved up in relation to other causes. Even children's hospitals report accidents create more admissions than infectious diseases.

Obviously something has changed, but 50 years is too short a span for any evolutionary change to have taken place in man himself.

Yet these stress diseases are real and have become today's killers. When a noted figure has a heart attack it is front page news, but aside from the associates, little is known of hundreds of other victims who are stricken on the same day.

Studies comparing the occurrence

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Welex, which recently added the Sidekicker to its list of Permanent Well Completion tools, now offers the most complete selection of PWC services to the industry.

Whether single or multiple completion, Welex on your well assures fast, safe and accurate service with a minimum of delay. That's why many Welex services and tools are standards of the industry, including:

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SWING-JET*—The standard of the industry for use in through-tubing work where maximum efficiency is desired. The carrier can be run through tubing as small as 1½" ID with seating nipple.

LINK-JET*—Here is a perforator for use in small diameter casing or for through-tubing work. The amount of debris left in the hole has been reduced.

SIDEWINDER*—Originally designed for tubingless completions, this gun leaves absolutely no debris in the hole, and when used with the Sidekicker, it perforates PWC well effectively without risk of damage to adjacent tubing strings extending downhole.

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Remedial PWC Services

Welex services and tools include everything needed for later remedial work on PWC wells. These include such standards as the:

- Through-Tubing Bridge Plug
- Through-Tubing Dump Bailer
- Flo-Master Flowmeter Survey
- Radioactive Surveys
- Tracer Surveys
- Temperature Surveys
- Welex Jet Tubing Cutter

In Permanent Well Completions, as in other types of completions, a complete package of tools and services means time saved and money saved. That's why Welex is your best choice every time.

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of stress diseases in the executive group with the occurrence of the same disease entities in the general company population, show almost exactly the same rate of incidence.

Other medical authorities have made similar studies and find the executive has no different pattern of disease than the general public.

To understand the nature of stress disease, it might be well to discuss some of the body's basic adaptation and survival mechanisms.

How you react to stress. When first exposed to any stress, the body becomes alarmed and over-reacts in a general way. This general reaction is somewhat inefficient in that all parts of the body react when they do not need to.

For example, if a sedentary worker is suddenly exposed to the stress of digging a ditch over the week-end, the entire body aches, not only the muscles stressed. If resumed the next day the work may be a little easier, and if continued thereafter at the same level, certain muscles will grow stronger. Unnecessary side reactions of a general nature will subside and the body will discipline itself into a state of efficient comfortable adaptation. The individual then meets his stress (physical work in this instance) with less effort, greater efficiency and less strain on the body.

It is known that psychological or emotional stress can likewise have the same effects.

The normal individual working under conditions found in modern industry for 8 or even 10 hours a day, particularly the executive, can hardly be said to be exposed to stresses incompatible with biological existence. It has been pointed out that spending $20,000 is no more difficult a decision for the executive than is spending $20 for the janitor. By the time he becomes an experienced executive, the businessman should have learned to function efficiently even with the pressures of his job.

Yet, the reality of stress disease cannot be ignored, for it is one of the great unsolved medical problems.

Coronary heart disease, arteriosclerosis, high blood pressure, gastric ulcer, colitis, migraine, allergies—all are on the suspect list of stress disease.

These diseases are very real and occupy top position in the mortality table. In searching for the causes of stress diseases, we must consider the nature of man's emotions and their place in the economy of his existence.

Four "keys" to survival. Roughly speaking, there are four basic phenomena of the nervous system which make it possible for man to adapt to and survive in an ever-changing environment. These are:

- Pain
- Hunger
- Fear
- Rage.

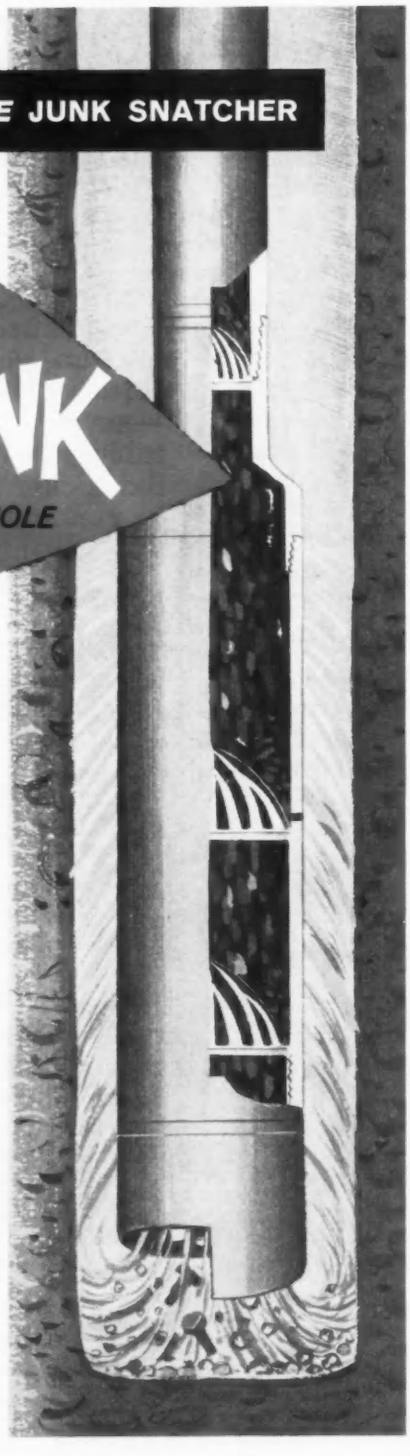
Few of us attempt to simply will away pain and hunger—not because we like them but because we can't control them through will alone and could not survive without them. However, although the same purpose is served by all four phenomena, man has quite arbitrarily decided that the Creator has made an error by putting fear and anger into him, and that this error must be corrected.

The purpose of these four phenomena is to promote survival by discip-

THE CAVINS *MULTI-SURGE* JUNK SNATCHER

GOES AFTER JUNK

IN CASING OR OPEN HOLE



GETS THE JUNK

Rubber, brass, plastic, aluminum, wood, and other non-ferrous materials (which could not be touched by magnetic tools).
Pieces of casing, wash pipe, roller shoe, carballoy mill, nipples, tong keys, packer slips, cones, nails, and even 12 feet of chain . . . all recovered by Cavins.

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Cavins multi-surge action gets MORE junk with FEWER runs! "100 linear feet of sand in one run" . . . "7 gallons of junk in 3 runs" . . . "one run cleans the hole after 4 days of fishing with other types of tools" . . . all routine with CAVINS.

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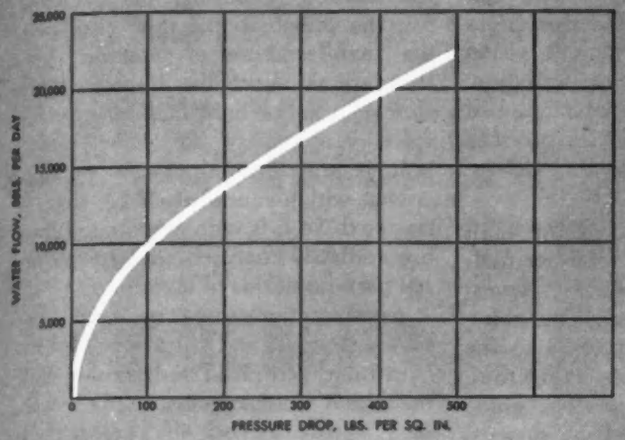
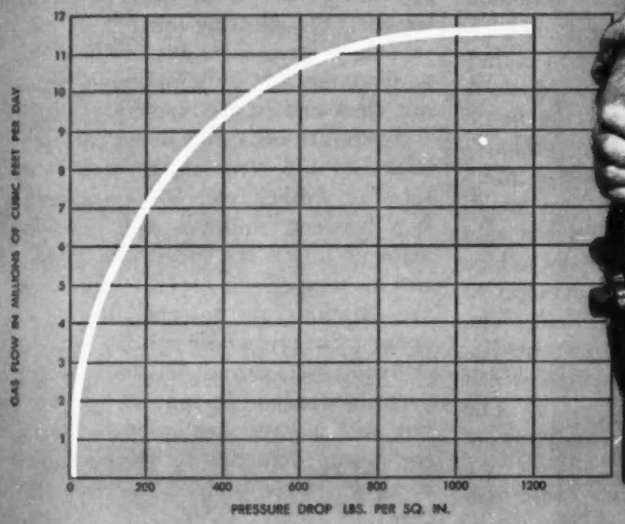
Passes Large Quantities of Fluid or Gas



FLOW OF WATER THROUGH UNIBOLT CHOKE WITH 1" SEAT



FLOW OF GAS THROUGH UNIBOLT CHOKE WITH ½" SEAT AT 2000 PSI INLET PRESSURE

if you could produce 10,000 bbls. per well per day . . .

. . . as the charts show, this UNIBOLT Adjustable Wing Valve would handle the fluid with only a 100-lb. pressure drop! Or, you could produce 28 million cubic feet of gas through it with only a 200-lb. pressure drop. So, while the UNIBOLT Adjustable Wing Valve is not a full-opening type, its one-inch flow area is far more than adequate for practically any desired production rate—*and the cost is importantly lower than for conventional gate and plug valves.*

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1. There are no exposed threads . . . no accidental damage.
2. All metal seats . . . not affected by high or low temperature.
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4. Stem turns freely under high pressures.
5. Threads on stem not exposed to external or internal damage.
6. Full 2½" pilot for true stem alignment and rigidity.
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linary control over the body. The pain caused by a cinder in the eye drives us relentlessly to protect our vision by locating and removing irritation. Hunger, almost always accompanied by aggressiveness, drives us to seek food; fear, to flee, rage, to defend ourselves.

There is nothing biologically built into man directing him to either foolish or self-destructive behavior. Nevertheless, any form of energy, including emotional, can be compressed to the point where it becomes dangerous. Natural, free-flowing emotions guide and direct man into healthy survival behavior, always gaged in quality and quantity to the needs of the moment.

The newspapers reported an incident where a plane dropped a live 200-pound bomb on a carrier deck. A sailor rushed over, carried the bomb to the side and threw it overboard, saving his own life and perhaps many more. The next day, when challenged, he couldn't budge a similar but safe bomb. Healthy, natural fear gave him both the courage and the strength to adapt to a dangerous emergency. The human mind and body may be likened to a computing machine which is useless without a power supply. The human power supply is emotion.

Behavior vs. emotions. Most men consider emotions a ridiculous weakness worthy only of scorn; the kind of nonsense that makes poor frail women cry apparently for no reason at all. We fail to note, however, that women in our culture frequently get, or get away with, whatever it was they were crying about.

Male children are taught that crying is a sign of weakness; that fear leads inevitably to cowardice, and anger, to the gallows. Most adults believe that self-pity is almost a cardinal sin and that worry leads inevitably to stomach ulcers. Consequently emotions are widely conceived as enemies to be conquered at all costs.

What then is the purpose of emotions which at best are seemingly useless and at worst harmful?

Nature does not do foolish things; all persons have emotions and they must have some logical function. Perhaps emotions themselves are not at fault—rather, it is our ignorance of their proper use and function.

It is impossible to measure directly the force of emotions. The rapid pulse, the labored breathing, the clenched fist, the punch in the nose—all these are manifestations of emotion; but, they are no more the force of emotion than is the light from a bulb the force of electricity. The light from a bulb is only a manifestation of electricity, which cannot itself be directly detected. So it is with emotions, which are endlessly confused with the external manifestations of emotion.

A distinction must be made between emotion and behavior. A hard-breathing, red-faced individual, flailing about destructively, is not necessarily undergoing the emotion of anger. Conversely, a pleasant, calm-appearing individual may be in an intense rage, plotting murder. A convincing actor can exhibit any behavior while internally anticipating a pleasant week-end in the country.

There are occasions when it is necessary to tell someone to stop some form of misbehavior but our confusion between emotions and behavior leads us to tell the individual to control his temper—or his fears. But these are emotions, the internal flowing of energy. Energy, whether it is electrical or emotional, cannot be destroyed or even controlled. It may be diverted but will always seek another outlet, for nature demands its release either in stress disease or useful accomplishment.

Know your "danger" signals. Emotions are functionally equivalent to pain. Pain orders all our behavior so that we operate in our own best interest. This is not selfishness in its commonly accepted sense of greed and meanness. It is healthy self-interest to remove a cinder from our eye and in no way conflicts with the rights or interests of others.

Similarly, emotions, by the pressures and tensions they create, tell us to look into our lives, see what's wrong, and fix it up, for it is almost always highly personal and defensive, and in no way conflicts with the rights or interests of others. To remain physically and mentally healthy we must accept this control which nature exercises through our emotions.

For every event in our lives there is an accompanying flow of emotion to organize the body to meet our problems correctly; yet, over and over, patients report they have no real problems—that the petty irritations in their lives are too trivial to be upset about. They seem not to realize that

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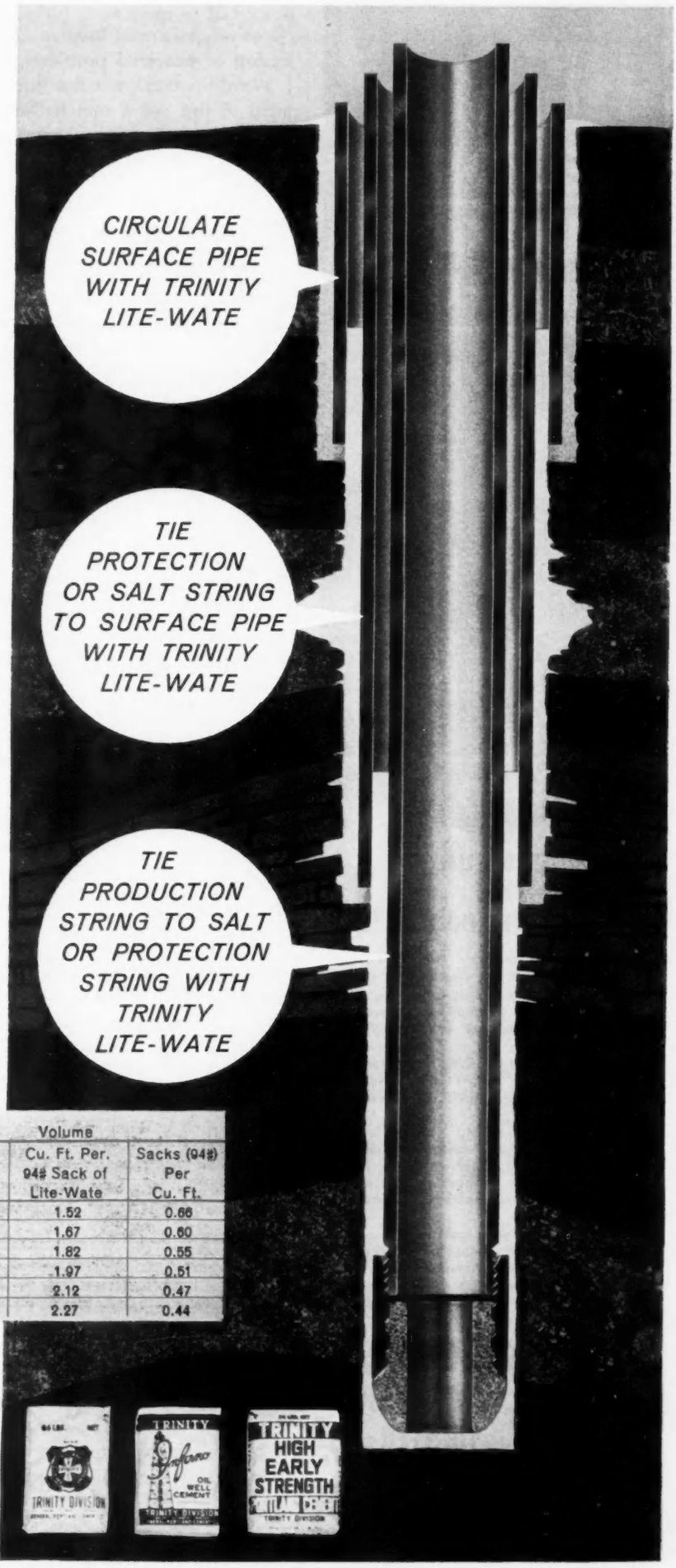
Trinity Lite-Wate is a neat oil well cement with a low slurry density. Nothing to add but water. It derives its light weight properties entirely from the high quality raw materials from which it is made. Easy mixing, easy pumping, can be circulated with low pump pressure and without loss to weak formations. It has proved satisfactory in circulating the surface pipe, tying protection or salt string to surface pipe and tying production string to protection or salt string.

Trinity Lite-Wate has been in use for several months in such varying well conditions as found in West Texas, Oklahoma, East Texas, Louisiana, Gulf Offshore and New Mexico, it has produced returns in *every case* where attempted.



SLURRY PROPERTIES

All slurries were mixed in accordance with procedures in API RP 10B. Slurry weight and volume were calculated on the basis of Lite-Wate specific gravity of 2.80.

Mixing Water			Volume		
Per cent	Gallons Per 94# Sack of Lite-Wate	Initial Viscosity Poises	Slurry Wt. Pounds per Gallon	Cu. Ft. Per. 94# Sack of Lite-Wate	Sacks (94#) Per Cu. Ft.
65	7.33	13	13.66	1.52	0.66
75	8.46	6	13.18	1.67	0.60
85	9.58	4	12.77	1.82	0.55
95	10.72	3	12.44	1.97	0.51
105	11.84	2	12.14	2.12	0.47
115	12.97	1	11.89	2.27	0.44

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PORTLAND CEMENT DIVISION
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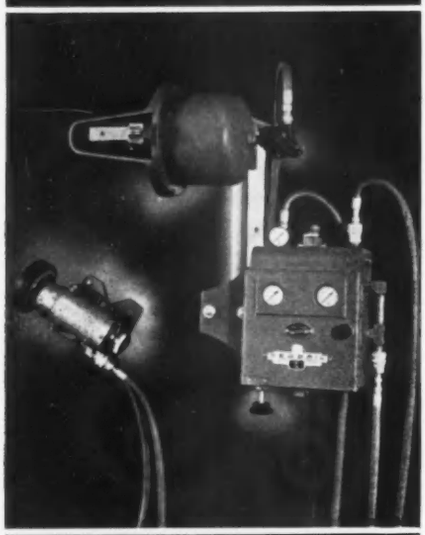

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if we fail to meet each little problem effectively, there is soon quite a collection of unsolved problems.

We do not call out the fire department to put out a match; but, if we do not put out each and every match, sooner or later we shall have a real conflagration.

On being repressed, all the little increments of emotional energy which accompany each event accumulate to a considerable feeling of tension, for the danger becomes more serious in the aggregate. Nature created man with an automatic fire department, but, man in his infinite wisdom has reorganized himself into ineffectiveness.

When tension rises high enough, it may begin to seek other outlets through perfectly innocent organs—the stomach, the heart, the blood vessels. This is Nature's second line of warning. Since we don't accept the warning of our emotions, she tries hurting us physically with pain.

At this point, the individual is diagnosed as being nervous. He, his family, his friends, his boss and often his personal physician have one prescription for treatment. This panacea consists of removing him from all unpleasant situations and insisting that he leave work, calm down and rest.

One of the most firmly held delusions is that emotional upsets are harmful and that worry is akin to taking poison. I have followed many cases in which people have been removed from more and more responsibilities until they become totally incapacitated and nonproductive—in effect, concealed pensioners. A problem cannot be solved by refusing to be aware of it or by evading our responsibility for its resolution.

Don't look for an "out." Experience indicates that there is very little inherent in the work situation, as such, to cause emotional difficulties.

Improper mechanisms, however, are brought into the work place by the sufferer. Usually they are techniques of avoiding unpleasantness, developed in earliest childhood for dealing with stressful situations.

An individual with a high degree of mental health will automatically seek and use effective mechanisms; conversely most people, having poorer mental health, suppress those mechanisms.

If an individual finds that things do not work out well for him, he must look within himself; it is rare to find a solution in the external environment. This is a painful process, usually avoided so long as our explanations and excuses for blaming something or someone else are acceptable.

When life becomes difficult, it is reasonable to want to get away, but the self-disciplined individual knowing problems are not solved that way has the courage to see the struggle through to a resolution.

An individual who habitually evades his responsibilities will repeatedly follow his usual pattern, but usually maneuvers the circumstances so that someone else has to protect him.

It is not always kindness to encourage this evasion by acting upon the individual's own prescription. It is usually kinder in the long run to handle the situation in such a way that he develops courageous patterns of behavior through solving his own problems with the accompanying greater security.

Physicians have known for centuries that self-diagnosis is extremely dangerous, and it is particularly true in emotional difficulties for the very mind needed to diagnose the trouble is itself not functioning efficiently.

The boss can help. The supervisor or executive cannot accept the subordinate's excuses for his failure. The superior has a serious obligation to examine all circumstances surrounding the subordinate's shortcomings.

Where circumstances indicate that the error lies in the individual's failure to adapt to the realities of his situation, the supervisor must in all fairness to the man, the organization and himself, exercise his authority to the end that the failing subordinate meets his responsibilities with effective personal action.

The supervisor who evades his responsibility for informing subordinates directly, accurately and in a straightforward manner of the facts regarding their performance, in turn creates unresolved tensions and stresses in himself, for his success is dependent upon their performance.

One of the most common complaints I heard from employes is that they are not clearly informed regarding their job performance. This is vital for all of us to know, for our jobs are our "bread and butter." Even job security, guaranteed by company policy when not earned by productive

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PALCO SEAL . . . an economical redwood bark fiber proven very effective in control of lost circulation of drilling fluids.

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EXPANDED PERLITES . . . a lightweight mineral which acts both to block the loss zone as well as lighten the fluid column during cementing.

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BDO (Bentonite-Diesel Oil) . . . commonly referred to as "gunk squeeze", acts to stop drilling mud lost circulation by forming a stiff gel. BDO is pumped down drill pipe and stiffens when contacted by drilling fluid which is pumped simultaneously down the annulus.

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JUST MINUTES AWAY FROM YOUR WELL

HALLIBURTON COMPANY
DUNCAN, OKLAHOMA

performance, will not provide the feelings of security we desire.

We may be able to fool society and our bosses and even ourselves about how well we are doing our job, but we can delude ourselves only for so long, because "Mother Nature" will not tolerate it. It profits little to have an unearned pay check if the price of self-deception is heart disease or stomach ulcer.

The common excuse for such failure to meet this basic supervisory responsibility is that the supervisor believes he does not like to hurt others, or that it is wrong to upset people. What he fails to recognize is that there is no way for anyone to evade his responsibilities for very long. To perform this unpleasant task we ourselves must first be upset. Since we believe emotional upsets harmful, we attempt to control our upset emotions, thus, aborting the drive to action. The end result is an increase in tension of all concerned.

Life is conflict. Modern man seems to have forgotten that life is basically a conflict.

The maintenance of life itself in the individual is a constant conflict between the body's need to maintain an internal steady state in the face of an ever-changing external environment. So is the struggle for existence among groups and societies. Democrats conflict with Republicans, labor with management—the list could be expanded indefinitely. Whether these conflicts should or should not exist is another question; but, it must be recognized that they do exist and are potential dangers. Ignoring the emotional warnings of danger does not remove the danger itself.

The full free life which sometimes includes a good scrap has been submerged in a utopian desire for eternal harmony and tranquility.

Lacking any realistic way of achieving it, man has developed the tranquilizer pill. Alcohol has long been a partial answer to man's desire for occasional false tranquility, but he knew the price was the next day's hangover. We have not yet learned what the body may have to pay for the tranquility of the tranquilizer.

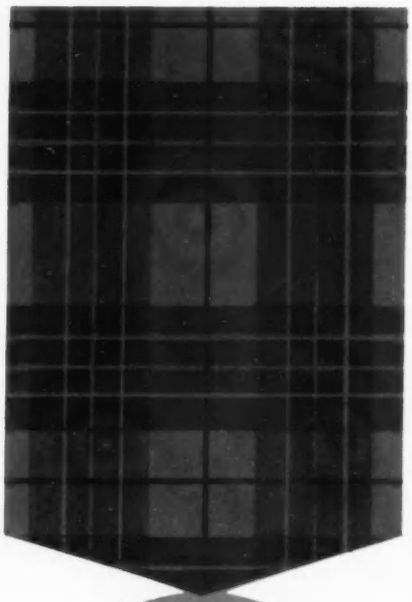
An individual who refuses to permit himself to become emotionally upset about a business situation because, in advance, he presumes it to be hopeless is missing out on solutions which might be forthcoming if he permitted his healthy emotions to motivate his quest.

Don't try the impossible. There is a widespread belief that management and supervision can and should make all their subordinates happy—not simply provide a healthy atmosphere in which they can find their own salvation.

It is an impossible task for anyone to make another person happy other than to so conduct himself that he does not unduly interfere with the individual's finding his own salvation. Yet, I have talked with supervisors who were thoroughly frustrated when an employe refused to be happy under their supervision, as though it were entirely the supervisor's fault.

There is in this situation a danger for the subordinate as well as for the supervisor. Creating an atmosphere which tacitly implies that the efforts will make an employe happy leads him to expect this miracle. When the efforts fail, employes are bitter and

WINNING COMBINATION by McKISSICK



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In Waterflooding: Strict Control of Sulfate-reducing and Sulfide-producing Bacteria In Brine as well as Fresh Water Systems.

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resentful. This is not to say that people do not react well to decent, fair, honest treatment, but can we do more?

To sum up, man brings most of his misfortunes, his failures and stress diseases upon himself by striving to make himself over into something allegedly finer and more nearly perfect than the Creator made him. His own strong, persistent, but delusional beliefs make him act as though he has accomplished it and he either fails to fulfill his normal obligations or demands impossible things of himself. Either extreme is equally hazardous.

He believes that he can free himself of anger and fear; he believes that he has powers to create a heavenly world of peace and harmony without conflict here on earth. He believes he can make all his associates, including his wife and family, happy.

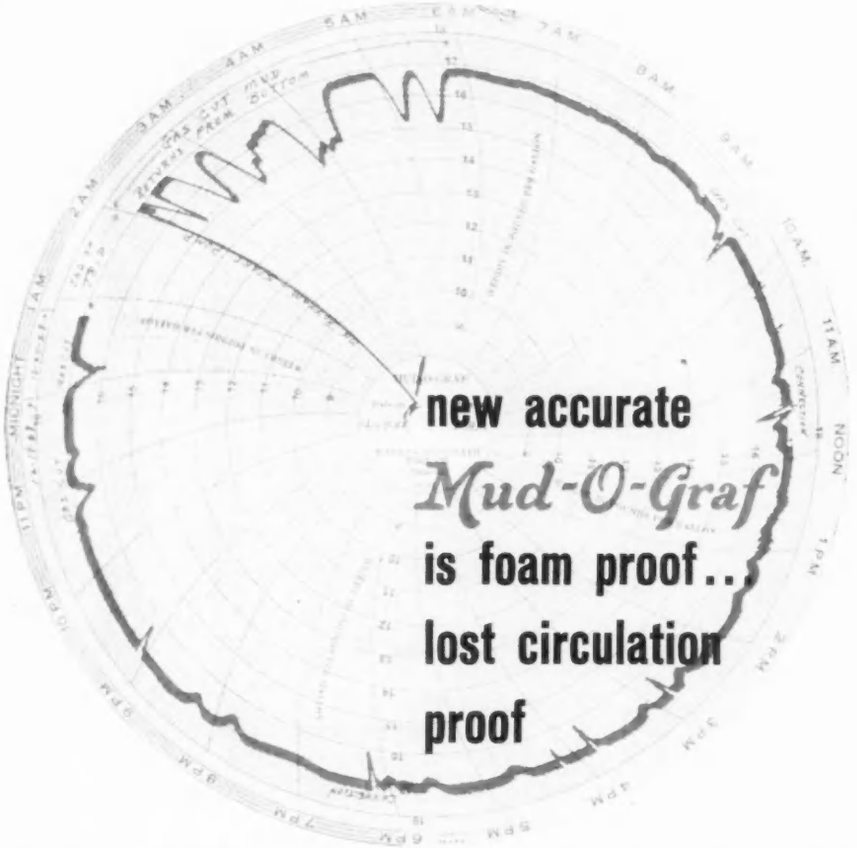
His normal elemental drives and motivations—anger, fear—are being repressed to dangerous destructive tensions in the false belief that they are inimical to the welfare of himself and the group. The results are, in effect, suicide in the form of stress diseases.

Modern man thereby has sacrificed his identity, freedom, independence, self-reliance and even his courage, in the damp laundry of mediocrity. The inevitable failure to make himself over into something less than nature intended leads him into frustration to which there is no end.

Frustration of the latter sort is quite different from the frustration which he deliberately seeks in playing golf. There is reasonable hope (although perhaps a slim one) that some day he can learn to play golf well. But, I cannot see any hope within the foreseeable future that he will be able to improve upon his fundamental physiological nature.

Rather than arbitrarily attempt to improve upon his, as yet ill understood, human nature, he might try to learn more about his true nature; for perhaps the Creator did a better job on him than he believes.

Presented before the 41st International Conference of the National Office Management Association, May 25, 1960.



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- A weighing unit that will handle lost circulation material or foamy mud.
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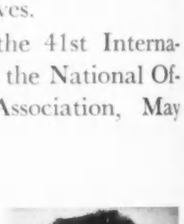
About the Author



Dr. Gerald Gordon is chief of Psychiatric Section, Medical Division, E. I. duPont de Nemours & Company and has been on the medical staff of this company since 1946. Graduating from the University of Alabama in 1934, with a B.A. degree, he continued there for two years in the School of Medicine. From 1936 to 1938, he studied at the University of Louisville's School of Medicine, receiving his M.D. degree. Following an internship at the California Hospital in Los Angeles, Dr. Gordon went into private practice for two years. He served with the civilian services in England in 1941 and from 1942 to 1945 served as a medical officer in military psychiatric hospitals with the U.S. Army in England. Returning to Wilmington, Del., after the war, he had a private psychiatric practice there for one year before joining the DuPont medical staff.

Your industry at work

A monthly roundup of items of interest about people, companies and associations

Shell's New Swamp Vehicle

Hitting the water for the first time is this new Shell Oil Company barge "Pogo," a self propelled vehicle especially designed for the inland waterways of the swamps of South Louisiana.

North Star Oil Buys Interests in Texas Wells

North Star Oil Company has acquired half interest in eight producing wells in Crockett County, Texas, from Dugger & Holmes, independent oil operators of San Antonio, Texas. The new purchase will add an estimated 100,000 barrels to company reserves. The transaction was for stock and cash.

It has been indicated that the eight wells have additional primary reserves and that secondary reserves can be obtained by waterflooding. Negotiations are underway with owners of the remaining 50 percent for remedial work and deepening to increase production. All are producing in the Grayburg limestock formation at approximately 2,500 feet on the Hoover Ranch in the Shannon field.

The transaction is the second in a planned program of acquisition by North Star in recent months. Last December the company purchased an interest in eight operating wells in Ector and Andrews counties, Texas. Additionally, the company is currently negotiating for three gas wells in San Patricio County, Texas, as well as remaining Hoover Ranch acreage.

Tekoil Announces Its New Oklahoma Acquisitions

Tekoil Corporation of Dallas and Oklahoma City has increased its Oklahoma holdings through three acquisitions involving 47 wells on 920 acres. The properties were acquired in three separate transactions. It also has been made known that secondary recovery and recompletion programs, including waterflooding, is expected to begin immediately on all properties.

The deals included 38 wells on 10 leases in the West Sasakwa field, Seminole County, acquired from Marvin Boyd, Dallas, for cash and an oil payment.

The other two deals are for cash and both involve leases in the N.E. Uncas field, Kay County. They include the G. C. Gales lease, involving six wells on 240 acres, purchased from C. L. Jenkins, Oklahoma City, and the Burch Lane Lease, involving three wells on 80 acres, purchased from R. C. Lillard, Shawnee, Okla.

Tekoil Corporation is an oil producing company specializing in secondary recovery with executive offices in Dallas, operation offices in Oklahoma City and regional offices in Midland, Texas.

Tidefleet Organized to Coordinate Flying A Fleet

The organization of Tidefleet Corporation, to coordinate certain activities of the expanding Flying A fleet of vessels owned and operated by subsidiaries of Tidewater Oil Company, has been announced by S. H. Harrison, president of the new corporation.

Tidefleet Corporation headquarters will be in the Pennsylvania Building in Wilmington, Del.

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SOUTHWESTERN

92

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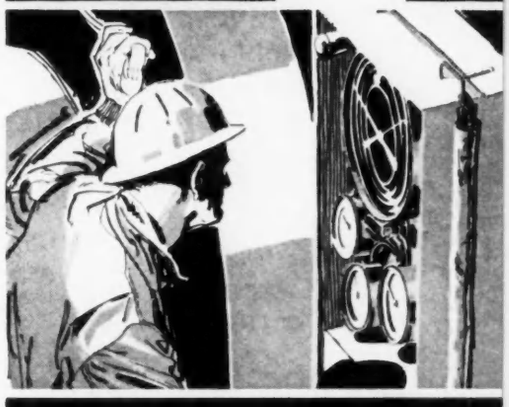

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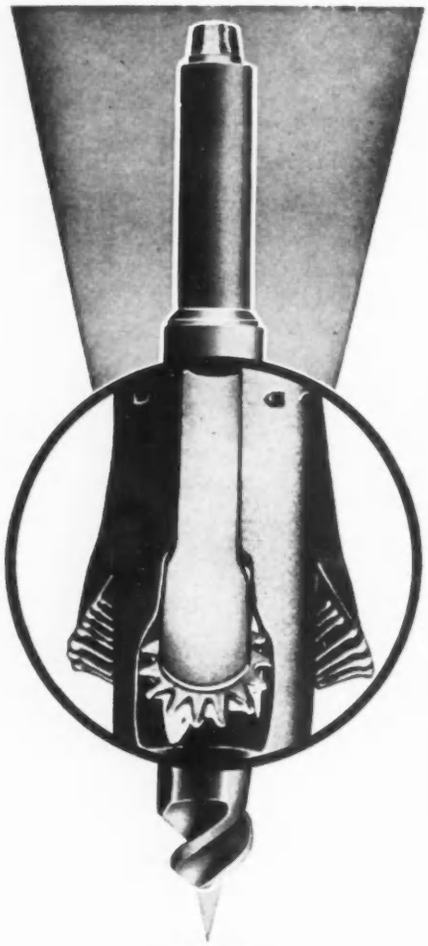

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Your industry at work

Standard Educational Grant To Benefit 130,000 Students

A $175,000 grant for education, to be shared by 159 privately financed liberal arts colleges with an enrollment of 130,000 students in 13 Midwest states has been made by Standard Oil Foundation, Inc. The grant to state associations of independent colleges makes a total of $1,325,000 given to them since 1952 by the Foundation.

Funds are allocated to member colleges by each state association in Colorado, Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Montana, Nebraska, North Dakota, South Dakota, and Wisconsin. No restrictions are placed on the use of funds as long as they are spent wherever they are needed to improve the education program. They may be applied wholly or in part toward operating costs, research, libraries, salaries or even building programs.

Mobil Oil Organizes West Coast Division

Organization of the Los Angeles Exploration and Producing Division of Mobil Oil Company has recently been announced. Mobil Oil is the operating company in the U.S. and Canada for Socony Mobil Oil Company.

With headquarters in Los Angeles, the Exploration and Producing Division will be responsible for land acquisition, leasing, exploration, drilling and producing crude oil and natural gas in California, Arizona, Oregon, Washington, Idaho, Nevada, Utah, western Colorado, northwestern New Mexico and Alaska. The new division is divided into three districts, Coastal, San Joaquin Valley and Rocky Mountain, with district offices located in Santa Fe Springs, Taft, Calif., and Durango, Colo. The exploration office for the San Joaquin Valley District is located at Bakersfield, Calif.

The area covered by the division is practically the same as was encompassed by the Production, Exploration and Land departments of General Petroleum Corporation which became a part of the Mobil organization on January 1.

R. O. Swayze has been named producing manager of the division with O. E. Van Meter, Jr., division engineer; M. W. Kibre, natural gas manager; B. H. Robinson, operations superintendent, and D. G. Kingman, joint interest manager. H. D. Hobson has been appointed division exploration manager with Joseph Neely, division geologist; W. P. Carver, division landman; and Klaas van der Weg, division geophysicist. Other staff appointments are R. P. Lavenant, Jr., senior attorney, E. R. Paul, employe relations manager, and J. O. Hills, division comptroller.

Superintendents for the producing districts are H. H. Carrick, Jr., Coastal; J. J. Oliphant, San Joaquin Valley, and P. M. Barry, Rocky Mountain. Exploration superintendents are E. R. Orwig, Coastal; C. L. Doyle, San Joaquin Valley and T. E. Hobbs, Rocky Mountain.

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Rainbo Service Co.....PL 6-2530
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Lucceus Service & Eqpt. Co.....MU 2-1631
OKLAHOMA CITY, OKLAHOMA
Rainbo Service Co.....ME 4-2131, ME 4-0105
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Davis-Kemp Tool Co., Inc.....435
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Men in the industry

Dr. Richard J. Gonzales, who has been coordinator of finance and economics since **Humble Oil & Refining Company's** recent reorganization into a nationwide company, has been elected a member of the board of directors. In addition to his assignments and duties as a director, he will be functionally responsible for finance and economics. **Herman P. Pressler, Jr.,** already a vice president and a member of the board of management of the Humble Division, has been named vice president and manager of public relations for the company where he will be in charge of directing and coordinating Humble's expanding public relations activities. **Dr. Charles F. Jones** who has been serving as manager of the Manufacturing Department of the Humble Division has been appointed to the newly created position of manager of the Economics and Planning Department. In his new post, Dr. Jones will be responsible for conducting economic studies of the petroleum industry and the general economy as well as for preparing other studies needed in planning the future course of the company. **Joseph L. Seger,** former president of the Carter Division, Tulsa, who joined the company's headquarters on June 1 as vice president for all public affairs (public and governmental relations), will be associated with Pressler.

Dr. R. J. Gonzales

H. P. Pressler, Jr.

Dr. C. F. Jones

J. L. Seger

Norman C. Miller, chief geologist, has been promoted by **Delhi-Taylor Oil Corporation** to the newly created position of manager of exploration. He will supervise all foreign and domestic exploration activities of the company. **J. D. Nunnally** succeeds Miller as chief geologist.

Lawrence J. O'Connor, Jr., Houston oil consultant and a top aide in the federal Office of Oil and Gas in Washington, D.C., has been named by Secretary of the Interior **Fred Seaton** as the new head of the government's mandatory oil imports control program. O'Connor succeeded **Capt. Matthew V. Carson, Jr.,** as oil imports administrator on July 1.

L. J. O'Connor, Jr.

S. J. Talley has transferred from the **Phillips Petroleum Company's** Bartlesville, Okla., headquarters to Midland, Texas, to assume the position of assistant division manager and division exploration geologist. **R. A. Wolgast,** formerly district landman at Durango, Colo., has moved to Denver as division landman.

Dick T. Fenwick, assistant manager of the Denver Division for **Sinclair Oil & Gas Company,** has been named assistant to Vice President **L. G. Rheinberger,** head of the Gas and Gas Products Department, Tulsa. **C. H. McClure,** assistant manager of the Tulsa Division, has transferred to Denver to succeed Fenwick.

Robert O. Anderson, president of **Hondo Oil and Gas Company,** Roswell, N.M., has been elected a member of the board of directors of **Northern Natural Gas Company,** Omaha, Neb.

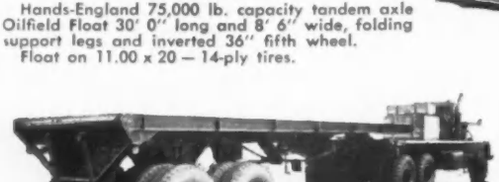
OILFIELD TRUCK AND FLOAT

Thornycroft Sandmaster 252" wheel base Oilfield Truck. Hands-England full Oilfield Body. 60,000 lb. winch, heavy duty gin poles, winch operated gin pole risers and folding SAE king pin.
Hands-England 75,000 lb. capacity, tandem axle Oilfield Float 30' 0" long and 9' 6" wide, folding support legs and inverted 36" fifth wheel.
Truck and Float on Michelin 18.00 x 25. Saharo "X" sand tires.

OILFIELD TRANSPORTATION EQUIPMENT

OILFIELD FLOAT

Hands-England 75,000 lb. capacity tandem axle Oilfield Float 30' 0" long and 8' 6" wide, folding support legs and inverted 36" fifth wheel.
Float on 11.00 x 20 — 14-ply tires.



OILFIELD TRUCK AND FLOAT

Scammel Constructor 261" wheel base Oilfield Truck.
Hands-England 75,000 lb. capacity tandem axle Oilfield Float 30' 0" long and 9' 6" wide, folding support legs and inverted 36" fifth wheel.
Truck and Float on 14.00 x 20—18-ply tires.

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B.M.I.

Men in the industry

Harry E. Haynes has been appointed division geologist in the Dallas headquarters office of **William J. Carey,** independent oil producer. Haynes was previously manager of the Carey Rocky Mountain operation. Before joining Carey, Haynes worked for The Pure Oil Company. **Dolf W. Fieldman** continues as district geologist in the Rocky Mountain area offices in Denver.

H. E. Haynes

Reese H. Taylor, chairman of the board of **Union Oil Company of California** since 1956, was re-elected to that position, and in addition, was elected president, an office he held earlier before he was made chairman. **A. C. Rubel,** president since 1956, recently retired. **Dudley Tower,** senior vice president, was elected executive vice president and continues to serve as a director and member of the executive committee. **John W. Towler,** director of manufacturing, and **N. T. Ugrin,** director of industrial relations, were elected vice presidents. **Morley E. Joyce,** supervisor of financial accounts, was elected assistant comptroller, succeeding **R. E. Dalbeck,** who has become director of the Budget Control Department.

Richard R. Anderson has been appointed director of production for **Sun Oil Company.** Formerly an administrative assistant to the production vice president, Anderson succeeds **Kingsley V. Schroeder** who recently was named vice president in charge of domestic and Canadian production activities. Also, **J. Dwayne Taylor** was appointed assistant to the director of foreign production operations, and **Thomas F. Ritter,** named assistant to the geological counselor for foreign operations.

R. R. Anderson

Edward M. Connaughton, senior economist, **Socony Mobil Oil Company,** has left for Tehran on a special assignment with the **National Iranian Oil Company.** He will help to organize the Iranian company's Economics Department.

John Knudsen, Jr., has been elected president of the **Kent Petroleum Company** by the board of directors.

J. W. Gwinn has succeeded retired **George Barnwell** as head of **Standard-Vacuum Oil Company's** exploration activities.

O. P. Thomas

C. F. McCoy

O. P. Thomas and **C. F. McCoy** have been elected to the board of directors of **Sinclair Oil & Gas Company.** Thomas was also designated an executive vice president, succeeding **Harry Jefferies,** retired, but continues as a director and chairman of the finance committee.

John D. Raunborg has been named assistant to the controller of **Kerr-McGee Oil Industries, Inc. W. Wayne Roberts** has taken over the duties as manager of internal auditing, the position previously held by Raunborg.

Richard G. Guerrero has joined independent oil operator **Cecil V. Hagen** of Houston as a geologist. Previously Guerrero was employed by Shell Oil Company.

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Associations

Four Corners Society Announces Third Field Conference Trip

The Four Corners Geology Society has announced plans for its Third Field Conference October 5 through 7. The trip will cover the salt structures of the Lisbon Valley and surrounding areas in the Colorado and Utah portion of Paradox Embayment for purposes of studying the geology of the Central Paradox Embayment. Homer E. Olivier is the field trip chairman.

Houston NOMAD Guests and Speaker

A large number of international guests turned out for the regular June dinner meeting of the Houston Chapter of NOMADS to hear Desmond Barry, president of Galveston Truck Line, who was guest speaker for the evening. International guests present were, standing left to right: Armando D. Reed, HOMCO De Mexicos, Mexico City; Rienhard Wohlbeer, (student) School of Mines, Clausthal, Germany; L. Bennarar, Y. F. P., Buenos Aires; G. W. Van Hillo, Shell Petroleum, Iran; Phillip Morris, Shell Petroleum, The Hague; speaker Desmond Barry, Galveston; P. G. Shaheen, U. S. Steel International, Maracaibo; and R. B. Standefer, Creole Petroleum, Maracaibo. Seated, left to right: Armando Castillanos and Ramon Velasco, Pemex, Mexico City; Hugh Gransaull, Hugh Gransaull & Co., San Fernando, Trinidad; Neil Beggerstaff, National Supply Co., Mexico City; Gerard Voisin, C. F. P. A., Algeria; Jon O'Conner, Hugh Gransaull & Co., San Fernando, Trinidad; and H. W. Van Gills, Shell Petroleum, Borneo.

Oil Heat Institute of America To Get Pittsburgh Chapter

A new chapter of the Oil Heat Institute of America will soon be chartered in Pittsburgh, Pa. Known as the Western Pennsylvania Chapter of OHI, the 35-member group is headed by Walter Young, president, a partner in the Suburban Oil Company of New Alexandria.

Other officers are Hartley King, King & Keeney, Inc., Boston, Pa., general manager; Francis Bartley of F. R. Bartley Sales and Service, Belle Vernon, treasurer, and George E. Kmetz, George E. Kmetz Oil & Gas Burner Service, New Brighton, secretary.

Purpose of OHI and its affiliated chapters is to further the use of oil heat through education of its members and a coordinated advertising program.

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K & G Drill Pipe Junk Shot breaks up hard-to-recover junk. K & G Magnetic Fishing Tools clean the hole. The K & G Adjustable Core Barrel Magnet protects costly core heads, speeds coring.

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WHO'S MEETING WHERE

Sept. 7-10	Eleventh Annual Field Conference, Billings Geological Society, Billings, Mont.
8-9	Louisiana-Arkansas Division of Mid-Continent Oil & Gas Association, Thirty-eighth Annual Meeting, Roosevelt Hotel, New Orleans.
11-13	New Mexico Petroleum Industries Committee, Annual Convention, Western Skies Motel, Albuquerque, N.M.
14-16	National Petroleum Association, Annual Meeting, Traymore Hotel, Atlantic City, N.J.
17-19	Biannual Symposium on Drilling and Blasting, Golden, Colo.
19-21	Texas Mid-Continent Oil & Gas Association, Forty-first Annual Meeting, Hilton Hotel, San Antonio, Texas.
20-21	Illinois Oil Industry Convention, St. Nicholas Hotel, Springfield, Ill.
20-21	Water Lift Institute, Court House, Liberal, Kan.
20-21	American Gas Association Organization Meetings, Hotel Cleveland, Cleveland, Ohio.
25-27	American Association of Oilwell Drilling Contractors, Twentieth Annual Meeting, Roosevelt Hotel, New Orleans.
25-28	American Institute of Electrical Engineers, Petroleum Industry Committee, Seventh Electrical Conference on the Petroleum Industry, Hotel Skirvin, Oklahoma City.
26-28	ASME Petroleum Mechanical Engineering Conference, Jung Hotel, New Orleans.
27-28	API, Executive Committee of Board of Directors, Greenbrier Hotel, White Sulphur Springs, W. Va.
29-30	Mid-Continent Oil & Gas Association, Mississippi-Alabama Division Meeting, Grand Hotel, Point Clear, Ala.
Oct. 2-5	AIME, Society of Petroleum Engineers, Fall Meeting, City Auditorium, Denver.
5-7	Third Field Conference, Four Corners Geological Society, Moab, Utah.
5-7	AIME, Rocky Mountain Minerals Conference, Newhouse Hotel, Salt Lake City, Utah.
6-7	NACE, Tenth Annual Western Region Conference, Sheraton-Palace Hotel, San Francisco.
6-8	Ninth National Cly Conference, Purdue University, Lafayette, Ind.
6-8	NACE, Southeast Region Conference, Dinkler-Plaza Hotel, Atlanta, Ga.
9-11	Tennessee Oil Men's Association, Fall Convention, Andrew Jackson Hotel, Nashville, Tenn.
9-12	ASTM, Committee D-2 Meeting, Mayflower Hotel, Washington, D.C.
10-12	American Gas Association, Annual Convention, Atlantic City, N.J.
11-14	NACE, Northeast Region Conference, Prichard Hotel, Huntington, W. Va.
12-14	Southwest Federation of Geological Societies, Third Annual Meeting, Wooten Hotel, Abilene, Texas.
19-20	NACE, North Central Region Conference, Schroeder Hotel, Milwaukee, Wis.
19-20	Gulf Coast Association of Geological Societies, Convention, Biloxi, Miss.

Nomads' Chapter monthly meeting: Los Angeles, second Wednesday, Jonathan Club, Wallace A. Sawdon, Secretary. Houston, second Monday, Ye Old College Inn, Harry E. Estes, Secretary. Dallas-Fort Worth, first Monday, Greater Dallas Club, Hank Davis, Secretary. Tulsa, Hotel Tulsa, Gilbert Swift, Secretary. New York, first Monday, Hotel Biltmore, Jesse E. Hickman, Seceretary.

Suppliers' notes

E. A. Johnson

J. G. Seiler

Elliott A. Johnson, vice president, Finance, and a general counsel, **Schlumberger Well Surveying Corporation,** and **John G. Seiler,** president, **Tube Turns, Division of Chemetron Corporation,** were elected president and vice president, respectively, of the **Petroleum Equipment Suppliers Association** by the group's board of directors at its annual meeting in Banff, Canada. **Wallace Wilson,** president of **Wilson Supply Company,** is the out-going president of PESA. Principal speaker for the annual meeting was **Alvin C. Hope,** president of **Independent Petroleum Association of America.** New district directors were also appointed. They include, Directors-at-Large: **E. S. Dulin, Byron Jackson Tools, Inc.; J. A. Crawford, The Youngstown Steel Products Co.; Frederick F. Murray, Oil Well Supply Division, United States Steel Corp.; A. W. McKinney, The National Supply Co.; Ted Sutter, Baker Oil Tools, Inc.; F. M. Mayer, Continental-Emsco Co.; M. B. Jones, The S. M. Jones Co. Division of Buffalo-Eclipse Corp.; D. D. Bovaird, The Bovaird Supply Co.; M. E. Montrose, Hughes Tool Company; Rainey Elliott, Jones & Laughlin Supply Division; Grover Kilgore, Halliburton Company; W. T. Powell, Continental-Emsco Co.; Wallace O. Wilson, Wilson Supply Co.**

Directors, Eastern District: **Karl Elliott, Acme Fishing Tool Company; W. H. Greer, W. H. Greer Supply Co.; Lloyd Lanphere, Ajax Iron Works; Donald W. Mackie, Jr., Bradford Supply Co.; J. T. Murray, Midway Supply Co.; F. E. Rath, Spang & Company; Craig Rowley, Parkersburg Rig & Reel Co. , Division of Parkersburg-Aetna Corp.; Paul Scherf, Alten Foundry & Machine Works, Inc.; John G. Seiler, Tube Turns, Division of Chemetron Corp.; H. Bernard Wehrle, McJunkin Corporation.**

Directors, Northern Mid-Continent District: **F. E. Bernsen, Lucey Products Corporation; W. L. Butler, W. C. Norris, Manufacturer; G. W. Carrington, Exner-Dodge, Inc.; Jene Harper, Franklin Supply Co.; K. W. Lineberry, Black, Sivalls & Bryson, Inc.; M. G. McCool, American Iron & Machine Works, Co.; W. J. McWilliams, Republic Co.; L. B. Meaders, Halliburton Company; A. C. Polk, Dowell Division of The Dow Chemical Co.; C. R. Zimmerman, Bethlehem Steel Co., Supply Division.**

Directors, Southern Mid-Continent District: **R. A. Baker, Cabot Shops, Inc.; K. W. Davis, Sr., Cummins Sales & Service, Inc.; Otto Hammer, Dresser Industries; S. J. Iverson, Iverson Supply Co.; W. H. Larkin, Larkin Packer Company, Inc.; R. H. McLemore, Otis Engineering Corp.; R. D. Poindexter, Superior Iron Works & Supply Co., Inc.; L. L. Rector, Rector Well Equipment Co., Inc.; Ray O. Shaffer, Welex, Inc.; T. N. Shults, Mid-Continent Supply Co.**

Directors, Gulf Coast District: **Herbert Allen, Cameron Iron Works, Inc.; George B. Coale, Baroid Division, National Lead Co.; G. B. Coleman, Bowen-Itco, Inc.; F. L. Hereford, Murray-Brooks, Inc.; Elliott A. Johnson, Schlumberger Well Surveying Corp.; L. A. Little, Lufkin Foundry & Machine Co.; John Maher, Reed Roller Bit Co.; J. J. Neale, Lane-Wells Company; Frederick W. Richmond, Houston Oil Field Materials Co.; Richard E. White, Mission Manufacturing Co.**

Directors, recommended for Pacific Coast District: **James Bere', Axelson Mfg. Co., Division of U. S. Industries, Inc.; H. J. Hagn, Chiksan Company; Harold E. Howard, Howard Supply Co.; Arthur S. Marshall, H. C. Smith Oil Tool Co.; I. J. McCullough, McCullough Tool Co.; H. H. Peters, Technical Oil Tool Corporation; John J. Pike, The Republic Supply Co., of California; Andrew W. Rose, Byron-Jackson Division, Borg-Warner Corporation; Elvin K. Wilson,**

A and B TUNGSTEN CARBIDE

for Hard Facing of

- Drilling Bits
- Tool Joints
- Rotary Shoes

When applied to tool joints, rotary shoes, rock bits and underreamers, A and B Tube Metal gives the oil industry the hardest, toughest, most uniform deposit of abrasive-wear resistant surface it is possible to obtain with manual torch or arc.

AVAILABLE SIZES*

Size of Rod	Tungsten Carbide Mesh Size
5/32 x 15"	30-40, 40-80, 40-100, 30-dn
3/16 x 15"	20-30, 30-40, 40-80, 40-100, 30-dn
1/4 x 15"	10-16, 20-30, 30-40, 40-80, 30-dn

BULK METAL

A and B Bulk Metal is clean, crushed tungsten carbide particles of uniform high quality, designed to give hard, non-porous, wear-resistant surfaces. Available in the following screen sizes:* 4-8, 8-10, 10-20, 30-40, 40-100, 10-200, and 200 dn.

*Special sizes available on request.

See Our Catalog in COMPOSITE CATALOG—Page 118

A AND B

Metal Mfg. Company, Inc.

Mfrs. of Tungsten Carbide

P. O. BOX 13125 HOUSTON 19, TEXAS

Suppliers' notes

Shaffer Tool Works; W. A. Wilson, Web Wilson Oil Tools, Inc.

S. A. Shuman

Sidney A. Shuman, general manager of the **Fluid Packed Pump Company Division** of **The National Supply Company,** has been transferred to Pittsburgh, Pa., as assistant to the president of National Supply. This is a new position. **James M. McFadden** has been appointed general manager of Fluid Packed Pump replacing Shuman.

Joe W. Hammond, staff supervisor of foreign operations for **Seismograph Service Corporation,** has been elected assistant vice president of the company.

J. D. Greensward has been elected president, **Canadian Allis-Chalmers Limited,** a wholly owned **Allis-Chalmers Manufacturing Company** subsidiary. He succeeds **Harold M. Schudt** who has been named director of Manufacturing, **Allis-Chalmers International.**

Fred A. Brock and **Donald P. Venker** have been named manager and customer requirements manager, respectively, of the **Geophysical Products Branch** of the **Texas Instruments Incorporated Instrumentation Group** at Houston. At the same time, **E. H. Urquhart** was named staff sales engineer for Texas Instruments.

Jack G. Clark

Jack T. Rodgers

Jack G. Clark has been appointed superintendent of the Houston plant, and **Jack T. Rodgers** has been named assistant secretary-treasurer of **Hunt Tool Company.**

Richard K. Teske has been named Chicago District manager for **Leschen Wire Rope Division, H. K. Porter Company, Inc.**

John R. Mills has been appointed sales manager of the **Rotadrill Division of Schramm, Inc.**

Lee Popham has recently joined the sales staff of **Brown Oil Tools, Inc.,** of Houston.

W. R. Timken was elected president of **The Timken Roller Bearing Company** at that company's recent annual meeting. Timken succeeds **D. A. Bessmer** who resigned.

Fly Delta's Big Jets from

Six U.S.A. Gateways

Convair 880's or **Douglas DC-8's** between

New York and Atlanta • Houston • New Orleans

Houston and New Orleans • New York • Chicago

Miami and Chicago • Detroit • Atlanta • Tampa

Chicago and Atlanta • Miami • Memphis Tampa • New Orleans • Houston

Detroit and Miami • Atlanta

New Orleans and New York • Memphis Chicago • Houston

Delta's Big Jets offer you the fastest, quietest, most luxurious flights ever!

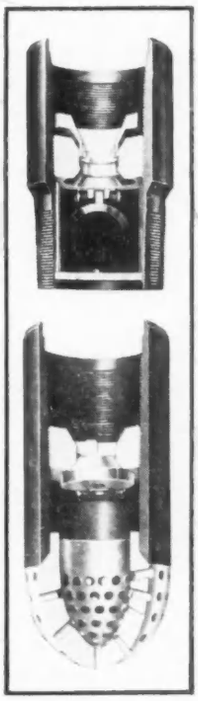
DELTA

the air line with the BIG JETS

RECTOR

Type "O" Fill Shoe and Collars

FOR MAXIMUM FLEXIBILITY



Rector Type "O" is the only automatic casing fill equipment that permits you to stop running pipe and circulate the well as often and for as long as you want and then resume running pipe with controlled orifice fill after circulating.

Only Rector Type "O" Gives You These Advantages:

- **Automatic fill-up increases safety—speeds running time—reduces pressure surges—protects the formation.**
- **Orifice choke in the spring-loaded flapper valve assures controlled constant fill.**
- **Precision rubber molded section on aluminum flapper valve assures positive back-pressure valve.**
- **Ceramic choke inserts are easily changed, making field maintenance easy, fast.**
- **Converts to float at operator's option.**
- **Internal parts are easily drillable aluminum alloy.**

Available through your favorite supply store for use in casing sizes 4" O.D. through 20" O.D. with standard threads.

RECTOR

Well Equipment Company, Inc.

1100 North Commerce Fort Worth, Texas
Houston Plant: 2215 Commerce

EXPORT REPRESENTATIVES:

Continental-Emsco Co.; Mid-Continent Supply Co.; Oil Well Supply Division of United States Steel Corp.

Suppliers' notes

Sidney A. Adger

Ralph Nobel

Sidney A. Adger has been elevated from vice president and director to senior vice president and director of **Milwhite Mud Sales. Ralph Nobel** also was elected to a vice presidency.

Clint B. Warren has been appointed regional sales engineer in the Houston office of **Delta Tank Manufacturing Company, Inc.'s**, Oil Field Equipment Division.

Hilmer A. Olson has been promoted to the position of export sales manager of **Bowen Itco, Inc.** Prior to his new promotion, Olson had been assistant export manager.

William S. Morris was re-elected president of **ALCO Products, Inc.** Three other directors were re-elected to serve three-year terms, they are: **LeRoy A. Peterson,** president of **Otis Elevator Company; Lawrence N. Murray,** a director of the **Mellon National Bank and Trust Company,** and **Wilson D. Leggett, Jr.,** vice president of engineering for ALCO.

R. O. Vaughn

Robert O. Vaughn has been appointed vice president, marketing of **Southwestern Industrial Electronics Company, one of the Dresser Industries.** Vaughn moves into the SIE position from his former post as western regional manager of government operations for **Dresser Industries, Inc.**

Luther C. Whalin has been appointed a field representative at Hobbs, N. M., for **U. S. Steel's Oil Well Supply Division.**

Clark W. Arnold has been named sales representative in the Rocky Mountain Area for **Well Equipment Mfg. Corp.**

Claude L. Griffin has been appointed sales manager for the Fort Worth Tool Division of **Chicago Pneumatic Tool Company.** He was formerly vice president in charge of sales for the Security Engineering Division of the Dresser Industries, Inc.

Bill Nelson has been appointed quality control manager of **Smith Tool Company.**

A and B "WEAR CUT"

The uniform cutting agent for fishing tools

A and B "Wear Cut," the newest addition to our tungsten carbide products family, is an effective cutting agent on rotary shoes, mills and reamers. It is manufactured under the most modern and efficient methods known in the Hard Metal Industry today. "Wear Cut" assures uniform grain size, eliminates flat slivers, and produces a rod with the **specified** amount of carbide and binder.

A and B "WEAR CUT" COMPOSITE ROD

ROD SIZE	MESH SIZE	% CARBIDE
3/16 x 15	10-18, 1/16-20, 1/8-1/16	60% ; 65%
1/4 x 15	3/16-1/8, 1/4-3/16	60% ; 65%
5/16 x 15	1/4-3/16, 3/16-1/8, 1/4-5/16	60% ; 67½%
3/8 x 15	5/16-1/4, 3/8-5/16, 7/16-3/8	60% ; 67½%

Write for prices on rods and/or bulk metal.

Engineering counsel is available. Let our tungsten carbide research center be your tungsten carbide center.

See Our Catalog in COMPOSITE CATALOG—Page 118

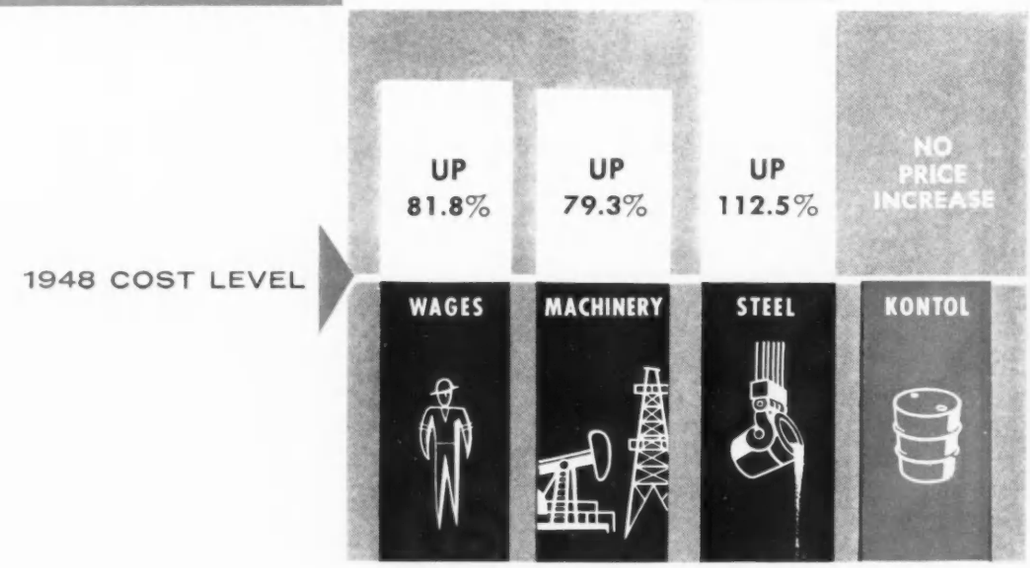
AND AB

Metal Mfg. Company, Inc.

Mfrs. of Tungsten Carbide

P. O. BOX 13125 HOUSTON 19, TEXAS

another
TRETOLITE SERVICE
report

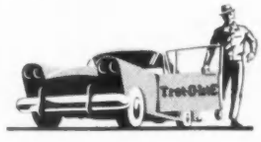


IN A PERIOD OF RISING PRODUCTION COSTS

KONTOL *prices are still at 1948 level!*

The Tretolite research staff constantly seeks ways to produce better KONTOL* Corrosion Inhibitor formulas for less money. This concern for *cost control* as well as *corrosion control* has kept the per gallon price of KONTOL at the 1948 level! Today, when costs of equipment, material, and wages are spiraling higher, it makes more sense than ever before to invest in a sound KONTOL corrosion control program.

Ask the Man in the Red Car how it can be done.



*Registered trademark, Petrolite Corporation

KF-60-3

PETROLITE
CORPORATION

SUBSIDIARY AND AFFILIATED COMPANIES
CANADA, Edmonton, Alberta • ENGLAND, London
GERMANY, Frankfurt, a. M. • VENEZUELA, Caracas

TRETOLITE COMPANY
DIVISIONS
369 Marshall Avenue, Saint Louis 19, Missouri
5515 Telegraph Road, Los Angeles 22, California

REPRESENTATIVES
ARGENTINA, Buenos Aires • BRAZIL, Rio de Janeiro • COLOMBIA, Bogota
ITALY, Rome • JAPAN, Tokyo • KUWAIT, Kuwait • MEXICO, Mexico, D. F.
NETHERLANDS, The Hague • PERU, Talara • TRINIDAD, Port of Spain

Suppliers' notes

Chuck Petrie

Art Hawkins

Jim Sayers

Jim Sayers has been appointed foreign sales manager of **Smith Tool Company** and will maintain offices at the company's main offices and plant in Compton, Calif.

Art Hawkins, former Coastal Division manager at Ventura, Calif., succeeds Sayers at the company's Edmonton, Alta., offices, and **Chuck Petrie** has become Coastal Division manager. He was formerly assistant division manager.

Lail Hamilton Shaw, Jr., has been appointed assistant district engineer at New Orleans for the **Oil Well Supply Division of U.S. Steel.** Shaw was appointed assistant district engineer in June 1958, and served in this capacity at Farmington, N. M., Ft. Morgan, Colo., and Houston, where he has been located since July 1959.

E. P. Hayes has been named consulting engineer and assistant in the sale of Lufkin pumping units and engines in all oil-producing areas for the **Lufkin Foundry and Machine Company.**

Allison (A. F.) Peters has recently joined the staff of **Joe Stein, Inc.**

W. D. Long

Allison Peters

William Dabbs Long has been appointed technical consultant for **Plastic Applicators, Inc.,** in the state of Mississippi, and **Charles W. Calhoun** has been appointed electronics research engineer for the firm.

Neal Clayton has joined **Geophysical Exploration Company** of Houston as a supervisor of field operations. He will direct and coordinate crew operations throughout Texas and Louisiana from the Houston headquarters.

Joe Manning, formerly vice president and general manager of **Stewart & Stevenson Services, Inc.,** has been named executive vice president; **Charles Ward,** acting as assistant general manager, has assumed the position as general manager; **Dick Conolly,** formerly South Texas district manager at Corpus Christi, Texas, has been named coordinator of branches and remains in Corpus; **Dick Grant** is the branch manager of the San Juan Branch; **Tom Langham** moved from the position of credit manager to general manager with offices in Houston and **Dick Anderson** is the new credit manager; **N. N. Elkins** is the new Corpus Christi Branch manager; **Howard Perkins** is branch manager at Beaumont; **L. D. Howell** has transferred to the Houston Sales Department, and **Harold Vaughn** is now service manager, succeeding Howell.

Charles M. Beeghly has been elected president of **Jones & Laughlin Steel Corporation.** He has served as executive vice president since April 1958, and as a director of the corporation since October 1957.

William A. Roever has been appointed manager of the newly created Dallas District office for **Clark Bros. Co., One of the Dresser Industries.**

The *original* sintered tungsten carbide composite rod . . . the rod with the highest concentration of properly sized fragmented tungsten carbide for the greatest number of cutting surfaces.

Hardest steel cutting tungsten carbide . . . matrix alloy with ultimate strength up to 100,000 psi.

Easily applied to fishing tools, bits, reamers, stabilizers, mills, rotary shoes.

SPECIFY KUTRITE, THE QUALITY HARD METAL

Kutrite ®
PAT. PENDING

Made Only By

B & W METALS COMPANY, INC.
P. O. Box 19042 Houston 24, Texas
Phone HO 5-6063

For more data on advertised products, use Readers' Service Cards, last page.

Suppliers' notes

J. B. (Johnny) Reeves has joined the **Tyson Smith Company** as the firm's Louisiana Branch manager. He will make his headquarters in Lafayette and will direct and coordinate sales and service activities of the firm's oil and gas process equipment throughout southern Louisiana.

J. T. Webster and **A. B. Edwards,** both sales correspondents at Tulsa, have been promoted to salesmen by **Jones & Laughlin Supply Division.** Webster has been assigned to the J&L's Williston, N. D., office, and Edwards at the Healdton, Okla., office.

New Company Announced by Dowell and Schlumberger

A new company, known as Dowell Schlumberger Corporation, has recently been formed by Dowell Division of The Dow Chemical Company and Schlumberger Limited. This new company will offer all Dowell services and Johnston Testers' drill stem testing in countries other than the United States and Canada.

Dr. A. P. Buetel, president of Dowell, will serve as chairman of the board of directors of the new corporation. Other Dowell members of the board are A. C. Polk and L. B. Swan. Schlumberger directors will be Jean Riboud, Guy E. Baboin and Gilbert Kerlin. Baboin will be president of the new corporation; Swan, vice president, and Tromer R. Smith, manager of operations. Headquarters are in London.

Firm Name Is Changed to Halliburton Company

The Halliburton Company officially became the new name on July 5 for what used to be known as Halliburton Oil Well Cementing Co.

The change of name was made because Halliburton provides a number of oil field services and products in addition to cementing and because the company has entered other industries to market several products and services originally developed for oil field use.

Murphy Safety-Switch Opens Houston Office

Frank W. Murphy Manufacturer, Inc., recently opened an office in Houston with Sidney Frakes, application engineer, to head up the new branch operation of the Tulsa firm. Stock, engineering and service facilities will be maintained by Frakes at 5111 Belmont Street in Houston.

In addition to Tulsa and Houston, the company has sales and service facilities in Los Alamitos, Calif., and in Calgary-Edmonton, Alta., through Petro-Automation Industries, Ltd., and in Caracas, Venezuela, through Madca-Edificio Galipan.

Jaeger-Cordray, Inc., New Representative for SIE

Jaeger-Cordray, Inc., has been appointed representative for Southwestern Industrial Electronic's Southeastern Region. The addition of this team to SIE's regional organization now gives the division nationwide coverage in all vital areas of military activity.

Jaeger-Cordray, Inc., has offices located at 3811 Colonial Drive in Orlando, Fla.

Continental-Emsco Opens New Louisiana Supply Store

Continental-Emsco Company recently opened a new supply store in Lake Charles, La. The occupancy of the new building enables Continental-Emsco to have all new stores in its South Louisiana Division. There are stores located at Venice, Harvey, Houma, Leesville, Morgan City, Lafayette and Lake Charles.

Nealy Nevils, Jr., is manager of the new Lake Charles store, which is under the supervision of Division Manager E. A. Dunn whose office is in New Orleans.

Midland Geophysical Acquired By Empire Geophysical, Inc.

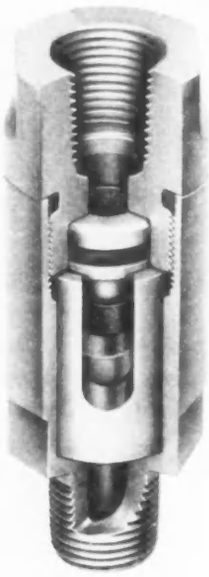
Acquisition of Midland Geophysical Company, Midland, Texas, facilities and personnel by Empire Geophysical, Inc., Fort Worth, has been announced by Howard Itten, Empire president. The acquisition was effective May 1.

Itten also announced the appointment of Lorenz Shock, who founded Midland

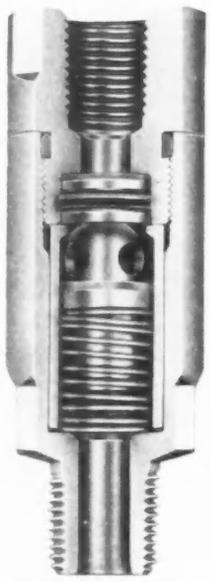
H B

Gas Lift Check Valves Prevent Damaging Backwash

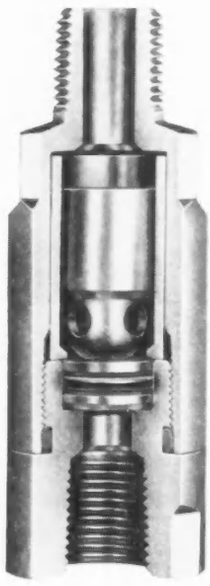
• Protect the heart of gas lift valves with Harold Brown normally seated check valves. Available in three types—"AM" Magnetic Check Valve—"B" Gravity Check Valve—"S" Spring loaded Check Valve.



Type "AM" Magnetic Check Valve
Positive Ball Seal
Non-weakening magnetic action
Insert seat, easily replaced
Made from Monel and high nickel alloys



Type "S" Spring Loaded Check Valve
Spring protected from flow stream
Heat treated K-Monel insert seat
Long life Monel spring



Type "B" Gravity Check Valve
Non-fouling Drop
Heat treated insert seat and drop

Harold Brown Check Valves fit all standard make gas lift valves. Ask your Harold Brown representative to show you all the superior features of H-B Check Valves.

HAROLD BROWN COMPANY

P. O. Drawer 25047 • Houston 5, Texas
Phone: JAckson 6-4411

HAROLD BROWN HOUSTON

Suppliers' notes

Geophysical, as Empire vice president and chief geophysicist. Shock organized Midland Geophysical in 1951.

The acquisition of Midland facilities and personnel enlarges Empire's crew operations to a total of 12 seismograph parties and 15 drilling units. The consolidation of the two companies' tape data reduction facilities in Midland will provide Empire with one of the most complete and versatile tape reduction centers in the United States, according to Itten.

U. S. Steel Issues First Casting License

The first license to produce castings of U. S. Steel Corp.'s patented "T-1" constructional alloy steel has been issued to the Los Angeles foundry, Alloy Steel & Metals Company.

Under an agreement, Alloy Steel & Metals is authorized to produce "T-1" steel castings in a wide range of products for a score or so of industries it serves throughout its primary market in 11 western states.

WORLD OIL'S Trading Post CLASSIFIED ADVERTISING

RATES: Regular Classified (undisplayed) set in this size type: 20 cents per word. Minimum charge $4. Blind box address in our care counts six words. Replies forwarded without charge. **Display Classified ads,** set in suitable larger type with ruled border, $13.50 per column inch. Ten percent discount for two or more insertions of same copy in consecutive issues. **All classified ads payable in advance.** Send copy and checks to: Trading Post Classified Section, World Oil, P. O. Box 2608, Houston, Texas.

FOR SALE

■ Core Drills, Auger Drills, Rotaries, Spudders, New and Used Equipment. Everything in Supplies. Pressey & Son, Pueblo, Colo.

BUDA POWER UNITS

Unused surplus, new condition. Four Cylinder, 121 HP Gasoline Engines. Complete with radiator. Twin disc clutch and 5 sheave V-belt drive pulley. Can be converted to LP or Natural Gas. Priced at fraction of cost, $1,495.00 each. Photograph and complete specifications on request.

OLDFIELD EQUIPMENT CO.
430 W. Seymour Ave., Cincinnati 16, Ohio

■ Two Reda Pumps for 5½" casing complete with control panels, No. 4 cable and protectors. One with transformer and generating unit. For additional information contact Tennessee Gas Transmission Company, Box 163, Great Bend, Kansas.

NOTICES - SERVICES

■ Financial Contacts, Underwriters, Private Brokers reached. Confidential. Send details to Consultant, 817 - 51st Street, Brooklyn, N. Y.

New Books and Maps

ELEMENTS OF PETROLEUM RESERVOIRS, Society of Petroleum Engineers of AIME, 6300 North Central Expressway, Dallas, Norman J. Clark, $7.

As the title implies, the author has written this book for the non-reservoir engineer who seeks a basic understanding of petroleum reservoirs. Throughout the book—from the description in Chapter 1 of how petroleum was formed to later chapters which present some of the more complex engineering concepts—the material is presented in a narrative, novel-like style which is free of mathematics and physical formulas.

Included are treatments of secondary recovery processes, operating oil reservoirs for maximum profits, use of natural reservoir energy, how pressure-production trends affect recovery in oil wells, how efficient rates of production may be determined, etc.

INTEGRATION AND COMPETITION IN THE PETROLEUM INDUSTRY, Yale University Press, New Haven, Conn., Melvin G. de Chazean and Alfred E. Kahn, $7.50.

For the first time an attempt is made to assess rather than to explain the effect of the gigantic size and integrated structure of the major participants in the United States petroleum industry upon the effectiveness of its competitive performance at each level of its operations. This book explains the extreme degree of integration in this industry in terms of its technology and of the historical occasions for the evolution of this form of organization.

PETROLEUM FACTS AND FIGURES, American Petroleum Institute, Committee on Public Affairs, New York, $4.50.

This 475-page volume, prepared by the Institute's Committee on Public Affairs, provides a comprehensive statistical history of the 100-year-old oil industry, including data on production, refining, transportation, marketing and utilization. It incorporates for the first time historical highlights on each of the industry's major divisions, a glossary of important terms and a bibliography.

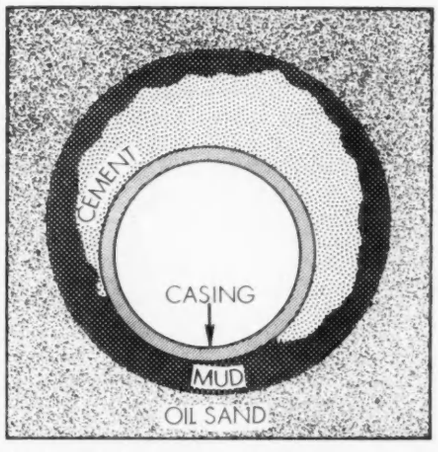
OIL AND GAS MAP OF MUHLENBERG COUNTY, KENTUCKY, Kentucky Geological Survey, University of Kentucky, $2.20.

An oil and gas map of Muhlenberg County, Ky., the first since 1930 to be compiled for the county. Muhlenberg County, located in western Kentucky, is one of the leading oil-producing counties of the State, producing more than a million barrels of oil annually. The map is 41 inches x 36 inches and is in two colors.

B and W Inc.
SCRATCHERS AND CENTRALIZERS
for a good cement job

CHANNELING
is defined as . . .

CHAN'NEL.ING 1. To form a channel in; to groove. 2. To convey into or through a channel or channels. 3. Oil Well Drilling. In well cementing, a condition resulting from incomplete removal of fluid, gelled mud and filter cake from behind the casing by the ascending cement slurry.



CHANNELING MEANS . . .
(1) An imperfect primary cement job
(2) Mud left behind the casing
(3) Expensive squeezing
(4) A poor completion

B and W
SCRATCHERS AND CENTRALIZERS

Your best and most economical insurance for the elimination of channeling and a good primary cement job.

B and W Inc.
Well Completion Specialists
GULF COAST
Box 5266
Houston 12, Texas
PHONE WAlnut 3-6603
WEST COAST
19706 South Normandie Ave.
Torrance, California
PHONE FAculty 1-2463
146

Announcing the new

MILLER

"SLIM HOLE" SAND PUMP

Miller 2" OD Sand Pumps for 2⅞" OD "Slim Hole" completions are now available. The 2" OD Sand Pump, with accurately machined lug-type bottoms, is designed exactly the same as larger Miller Sand Pumps.

SAND PUMP SIZES

O.D—2, 2½, 3, 3½, 4¼, 5, 5½, 7 in.
Lengths—20, 25, 30 ft. for 3" OD and larger pumps. 20 and 25 ft. for 2½" pump. 20 to 24 ft. for 2" pump.

Composite Catalog, Page 3688
Write for descriptive price list

MILLER SAND PUMPS

Miller Sand Pump Co.

General Offices, Box 4516
Oklahoma City 9, Okla.

EXPORT OFFICES
30 Rockefeller Plaza
NEW YORK CITY 20, N. Y.

Superior
OIL TOOL
SERVICE COMPANY
INCORPORATED

- CASING MILLING
- FLAT BOTTOM JET MILLS
- WHIPSTOCKS
- WIRE LINE CORING

P. O. BOX 22191
HOUSTON 27, TEXAS
JACKSON 8-6138

SQUEAKS from the BULLWHEEL

"They're getting oil out of the land and sea—what are they up to now!"

Problem Parents

To be honest, the real reason it's so hard to bring up children right is that they insist on imitating their parents.

South of the Border

Pancho, a school boy, was asked by his teacher: "Pancho, what does your father do?"

"I have no father, teacher. He was killed by the weasel."

"Killed by a weasel? . . . How could that be?"

"He was seeting on the railroad track," Pancho explained, "And he deed not hear the weasel!"

Our Growing Children

A class of 10-year olds had been instructed by their teacher to write a story on some category of cleanliness and health. One little fellow's treatise—labeled "Care of the Teeth"—listed in order:

See your dentist often.
Brush your teeth every morning and every night.
Watch out for shovers at the drinking fountain.

Ain't It the Truth

A young woman boarded a crowded bus. A tired little man got up and gave her his seat. There was a moment of silence.

"I beg your pardon?" said the tired little man.

"I didn't say anything," replied the young woman.

"I'm sorry," said the little man, "I thought you said, 'Thank you'."

In Technicolor and Cinemascope

"Have you read Webster's Dictionary?"

"No, I'm waiting for the movie."

The Hollywood Rage

Did you hear about the new Hollywood western? It's a psychological horse opera. At the end of the picture, the horse cracks up.

There Is a Difference

Traffic Rate Clerk: "My girl friend is a twin."

OS&D Clerk: "She is? How can you tell them apart?"

Traffic Rate Clerk: "Her brother is built differently."

Famous Last Word

Old reservoir engineers never die—they just lose their material balance.

Old colleges never die—they just lose their faculties.

SECONDARY RECOVERY

PETROLEUM ENGINEERS
STEPHENS ENGINEERING
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Water Flooding Gas Repressuring
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McCULLOUGH
SALINITY LOG
with scintillometer®
...a nuclear log that tells
OIL *from* SALT WATER

The McCullough Salinity Log determines the presence and degree of saline fluids in formations surrounding the bore-hole. It will distinguish between oil and salt water and can be used in open or cased hole. Providing hole diameter is not extreme, it may be used where air or gas or highly saline fluid was used for drilling.

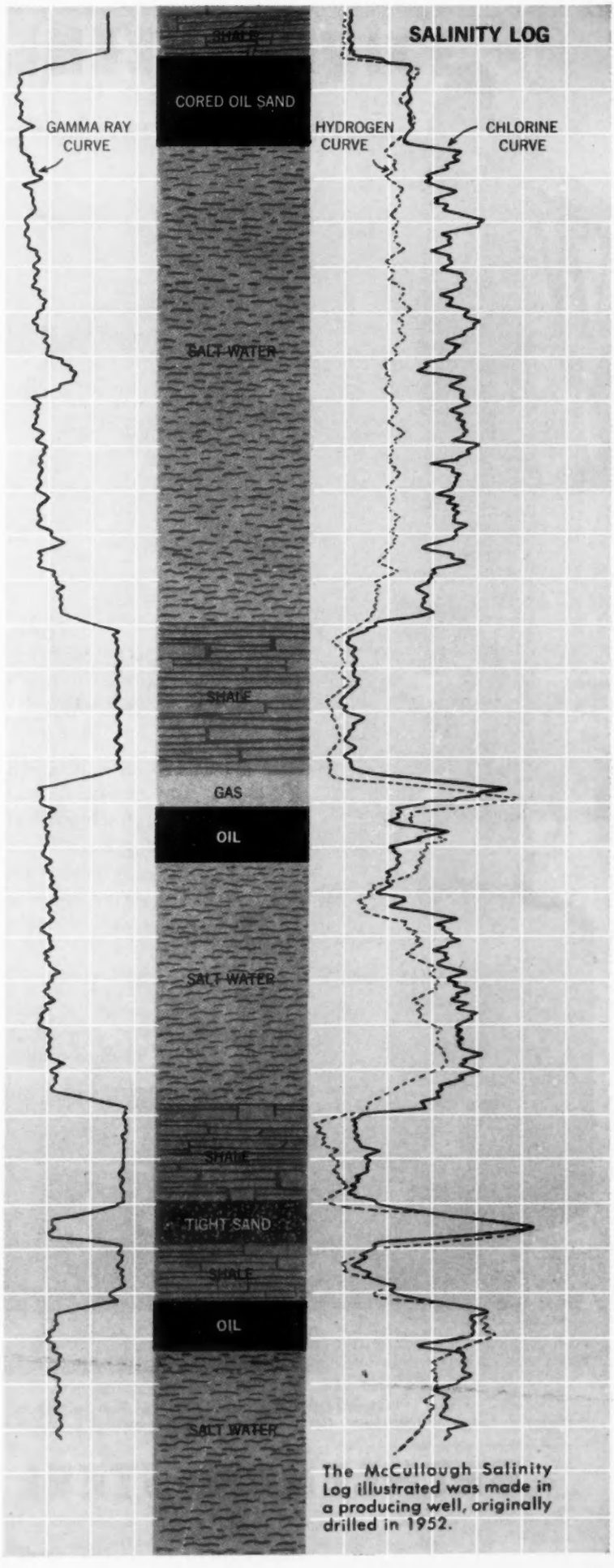
A "chlorine" curve and a "hydrogen" curve are recorded simultaneously at the same depth elevation with a single detector. These curves are compared to indicate the amount of salt, NaCl in particular, that is present in the formations being investigated. In potential oil bearing formations the absence of salt is indicative of the presence of oil.

The recording of the two curves simultaneously is considered essential. It eliminates the possibility of a depth discrepancy between two curves which are recorded separately. It also insures the recording of information under identical physical conditions—of extreme importance in interpreting the two curves.

A higher counting rate and greater instrument efficiency allows an increased spacing (23½ in.) between the source and the Scintillometer. This provides the added benefit of a proportionately larger zone of investigation.

Take a look at these features:

- **Distinguishes between salt water and oil in liquid bearing formations.**
- **Determines the degree of salinity in formation fluid.**
- **Identifies salt water zones that must be blanked off.**
- **Makes possible water saturation calculations for potential oil bearing zones.**
- **Shows salt water and oil zone contact under suitable conditions.**
- **Aids in determining gas/oil contact.**
- **Helps determine if it is economically practical to set casing on new completions.**
- **Aids in evaluating correct depth to set casing string.**
- **Accurately re-evaluates old wells to locate potential cased-off production.**
- **A reliable tool for porosity determination.**

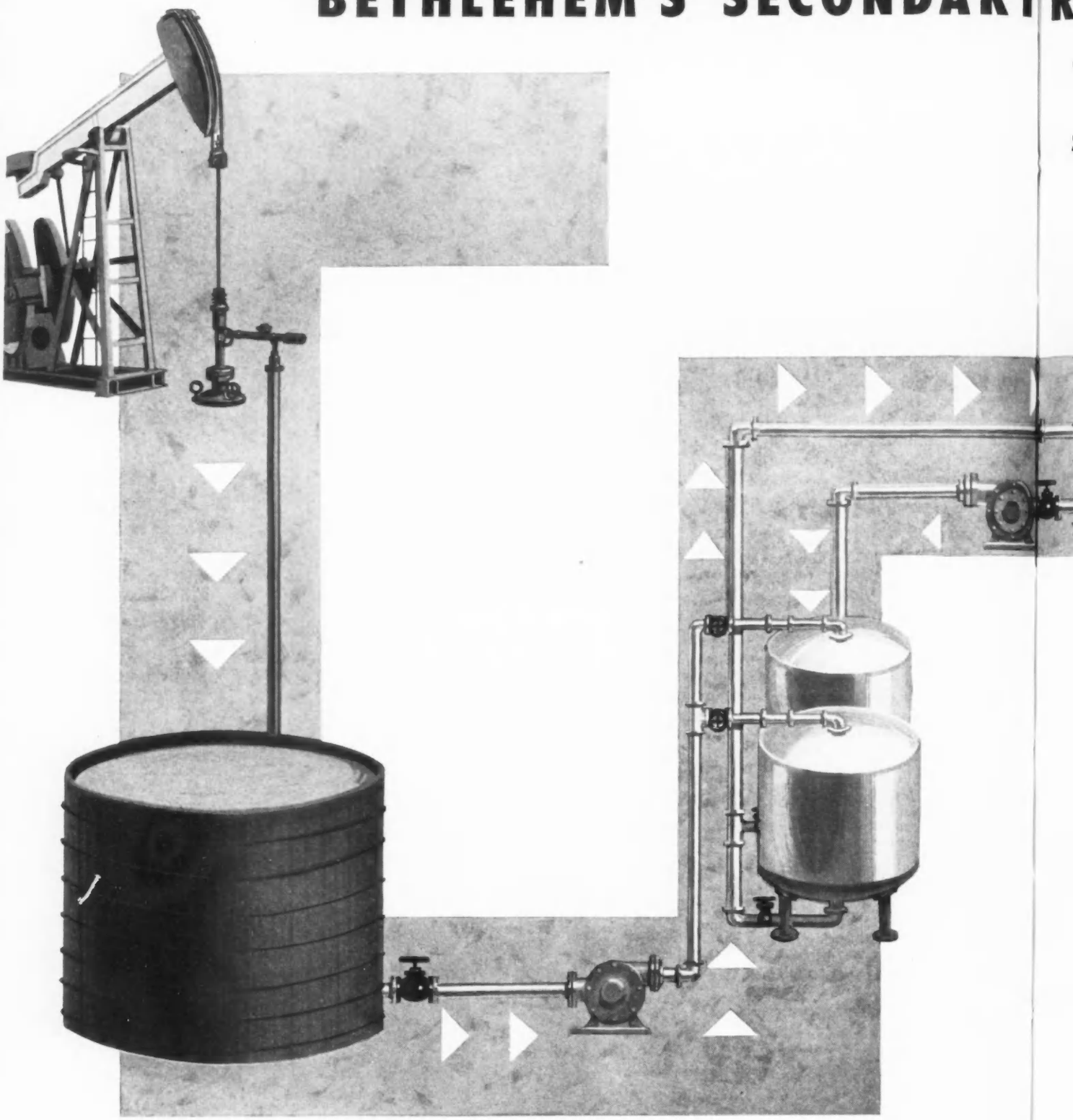


The McCullough Salinity Log illustrated was made in a producing well, originally drilled in 1952.

McCullough
TOOL COMPANY
Los Angeles • Houston • Edmonton
Cable Address: MACTOOL

For more data on advertised products, use Readers' Service Cards, last page.

BETHLEHEM'S SECONDARY R



BETHLEHEM STEEL COMPANY
SUPPLY DIVISION
General Offices and Export Dept.: 21 East Second St., Tulsa, Okla.
Canadian Distributor: Bethlehem Supply Company of Canada, Ltd., Calgary, Alberta, Canada

BETHLEHEM STEEL SUPPLY DIVISION

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takes care of everything from the supply well to the injection well

Let Bethlehem handle planning, design, equipment, installation . : : even the final check on the operating plant. We have handled well over one hundred successful waterflood projects throughout the oil country. Our engineers are experienced in designing within virtually every type of water, well, and weather condition. They *know* secondary recovery, and have all the experience necessary to make your projected program a profitable one.

Complete turnkey services

ENGINEERING—After determining the special mechanical and economic requirements of the particular project, we prepare working drawings which specify the proper equipment and determine its operating location. Every phase of construction is detailed with full regard for special considerations, such as the possible future expansion of the plant, or the portability or reclaimability of individual units.

EQUIPMENT—When operating under turnkey contract, we purchase, schedule for shipment, and receive on location each piece of equipment specified for installation. Pumps, prime movers, drives, automatic controls, instrumentation, piping, filters—everything needed for the entire project is ordered and expedited by our own purchasing department. When the plant is completed, we issue to you what is in effect a single invoice covering all three phases of our service: engineering, equipment, and construction.

CONSTRUCTION—Bethlehem's turnkey service includes the construction of everything on the project site. Our engineers supervise the erection of the tanks and buildings, as well as the installation of all equipment and connecting lines. When the plant has been checked out thoroughly and is operating as designed, it is turned over to you.

Let us tell you more about Bethlehem turnkey and package services. Any of our 53 offices and stores can supply full details.

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Sales Department WO
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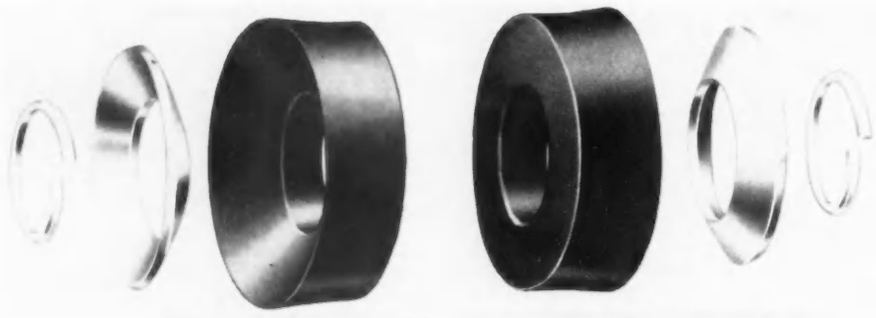
NEW equipment and services



New Pump Equipment

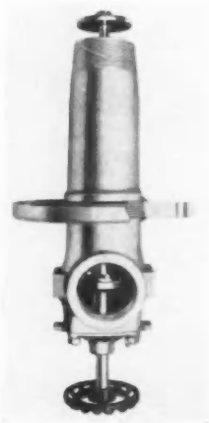
A complete line of pump pistons and replacement rubbers has been designed and recommended for service with waterbase drilling fluids. New "regular" rubbers are interchangeable on the Guiberson one-piece forged steel piston hub which need not be removed from the rod when rubbers are replaced. Rubbers molded to provide a predetermined, well calculated lip interference with the liner wall. (The Guiberson Corporation, One of the Dresser Industries).

For more data, circle E1 on postcard

Improved Oil Saver

This improved oil saver can be installed without cutting the line, which means great savings in wire line stripping cost. Other features effecting wire line stripping economies are: Rubber wear is compensated by hydraulic pressure furnished with a standard grease gun; all steel construction; wear parts easily accessible and easily replaced; one-piece, low-priced replaceable packing, rubber and line guide, and clearance inside for 1¾-inch rope socket. (Saunders Brothers. Supplements data on Page 4824, 1960-1961 Composite Catalog.)

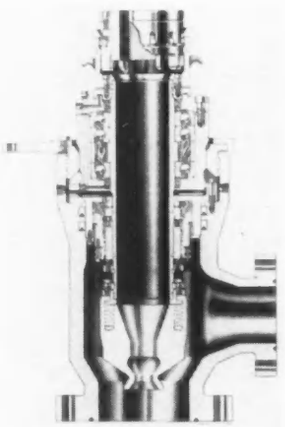
For more data, circle E4 on postcard



For more data, circle E2 on postcard

Water Draw-Off Valve

This new valve features packless, double seat and non-freezing construction. Two seats or valves are mounted on the same stem. Inner valve, left, seats first, permitting the chamber between the inner and outer valves to drain before the outer valve is closed. Cap on the end of the valve body and the outer valve can be removed and the seat on the outer valve is replaced, while the inner valve remains closed against the tank products, thus, permitting the valve to be serviced without the expense and inconvenience of emptying the tank. (The Johnston & Jennings Company.)



New Weight Indicator

A new anchor type weight indicator has been developed for the small drilling rig, workover or production hoist. Type "G" provides all the advantages of the Type "D," "E," and "FS," used on larger rigs, but is scaled down to be light in weight for the stringent requirements of portable rigs. The National Supply Company Type "G" Deadline Anchor is side-mounted to the derrick leg or other structure, and provides a permanent mounting for the Sensater pressure signaling device. (Martin-Decker Corporation. Supplements data on Pages 3517-3548, 1960-1961 Composite Catalog.)

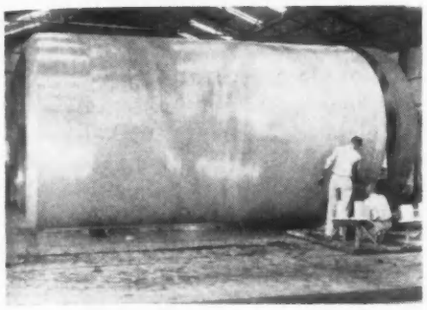
For more data, circle E3 on postcard

Rotating Kelly Packer

The new Hydril Type "LS" Rotating Kelly Packer is now available for use with any blowout control equipment. It is completely self-contained within its own housing. Packer consists of central ball-bearing-mounted sleeve, provided at its upper end with a driver to engage the kelly drive bushing, and at its lower end with a steel-reinforced rubber stripping packer which seals around and rotates with the kelly. (Hydril Company. Supplements data on Pages 2777-2896, 1960-1961 Composite Catalog).

For more data, circle E5 on postcard

New equipment



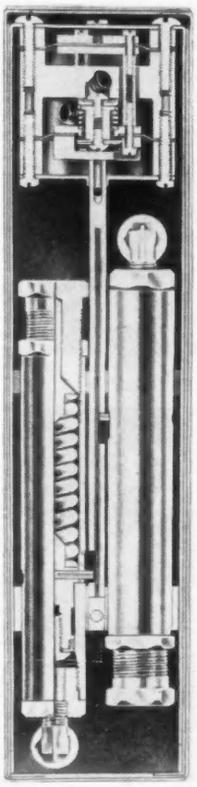
Poxyglas Tank

Poxyglas, a new type of corrosion-resistant tank, has been made available. Poxyglas is an epoxy resin-bonded, glass filament-wound tank that is applicable in the storage of sour crudes, waterflood and salt water disposal processes, and for offshore and other areas where external corrosion is a problem. It is resistant to all fluids normally encountered in oil field production—salt water, sour crude, fresh water, carbon dioxide, hydrogen sulfide and treating chemicals. (Black, Sivalls & Bryson, Inc. Supplements data on Pages 685-704, 1960-1961 Composite Catalog).

For more data, circle E6 on postcard

Pressure Control Pilot

A new high-low pressure control pilot, called the Type E-1, has been developed with separate high and low pressure sensing elements to allow pressure to be taken from two separate points. E-1 is used as a pressure safety control high-low shut-off and for well purger, back pressure and pressure reducer service. Wide pressure range (0-2,000 psi) is available through the use of interchangeable pressure range springs. (Merla Tool Company. Supplements data on Pages 3679-3684, 1960-1961 Composite Catalog.)



For more data, circle E7 on postcard

New Combination Bit

This new combination bit combines the desirable features of both the drag and rock bit to produce a superior drilling tool for soft and intermediate formations. Advantages: Higher penetration rates, straighter holes, lower torque, less weight and smoother rolling action. Cones, cutting at and near the periphery of the hole, serve as a pilot, keeping the hole straight and to gage. (Hunt Tool Company. Supplements data on Pages 2713-2760 and 1848A-1848D, 1960-1961 Composite Catalog).

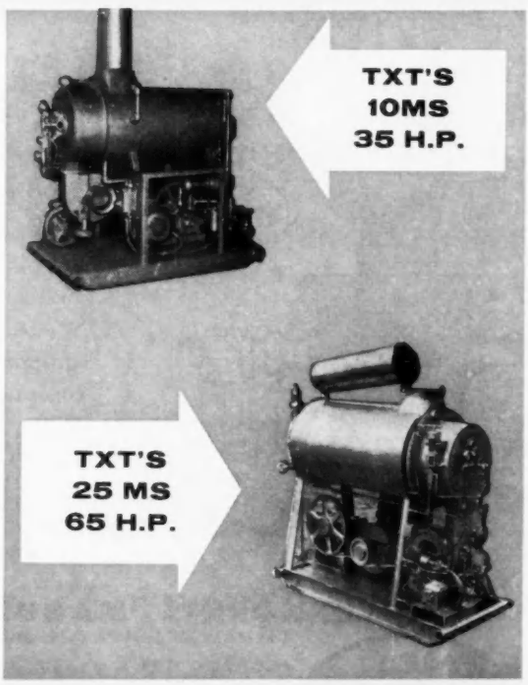
For more data, circle E8 on postcard

"Texsteam's Rig Heaters Proved Safe And Dependable In Every Installation"

Heat in just 3 minutes

Here's one heater meeting ALL the requirements of a power rig for dependable source of heat in cold weather operations. Available in two sizes (1 Million and 2½ Million BTU output), this compact, packaged boiler is completely safe, cannot explode under any conditions, and is easy to operate. No firing-up period, no cooling off period is necessary and it reaches maximum volume within three minutes.

An important feature is that the heater and entire heating system may be filled with diesel oil or anti-freeze to prevent freezing while the rig is shut down. The Texsteam rig heaters have more than adequate steam volume to keep the rig floor comfortable, heat the change house, keep mud at workable temperature, prevent freezing of blowout preventers and other vital fluid control equipment, as well as supply live steam for cleaning. Write for catalog with complete details.



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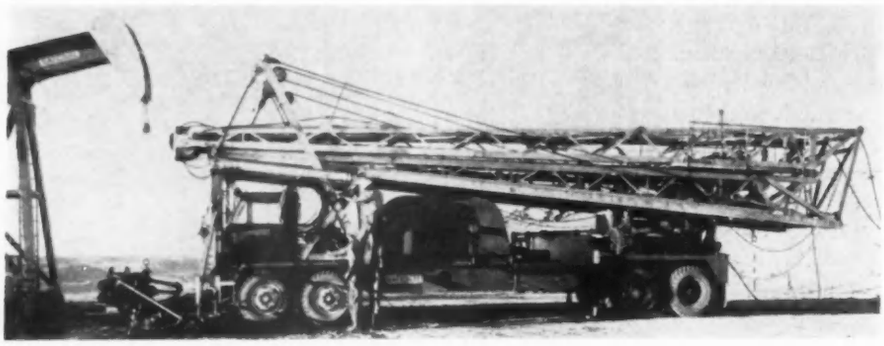


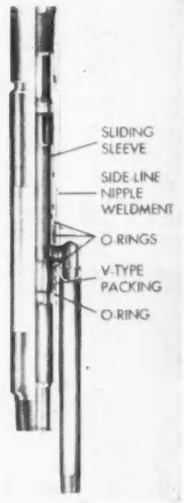
Service and Workover Rig

This multi-purpose, self-propelled drive-in type unit is designed for every oil field job from rod and tubing servicing to deep workover. Model 200 has a depth rating of 8,000 feet, with a nominal range of 150 to 250 horsepower. In operation, it is centered close to well. Truck is leveled on four jacks, outriggers are swung into position and engine drive is shifted to the drawworks. Model 300-B has a rating of 12,000 feet with a nominal range of 250 to 350 horsepower. (The National Supply Company. Supplements data on Pages 3849-3976, 1960-1961 Composite Catalog).

For more data, circle E9 on postcard

New Crossover Tool

A new crossover tool has been developed for use in single string dual producers having a wide pressure differential between the two zones. Tool is designed to prevent the zone feeding problems often encountered with conventional crossover equipment while checks are being changed. Tool is full opening to permit necessary wireline operations to be performed on on the lower zone, and makes PTWC of the lower zone optional. (Otis Engineering Corporation. Supplements data on Pages 4269-4364, 1960-1961 Composite Catalog).



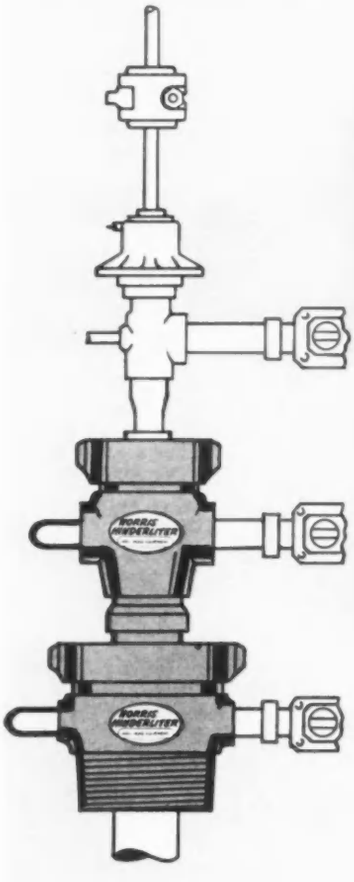
For more data, circle E10 on postcard

Centrifugal Mud Pump

A new side-suction centrifugal mud pump for supercharging slush pumps and for reduction of pump power end shock loading is now available. New 4 and 5-inch BN mud pumps allow slush pumps to be operated at maximum pressures and capacities, resulting in longer life of fluid end parts and pistons. Features include: High carbon steel shaft; turned, ground and polished to size; shaft is chrome plated at packing area for longer life. (Gardner-Denver Company. Supplements data on Pages 1993-2028 and 3549-3572, 1960-1961 Composite Catalog).

For more data, circle E11 on postcard

Engineered Simplicity



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